THE *Petroleum* Engineer — Management Edition

Exploration—Drilling—Producing • Refining—Petrochemicals—Gas Processing • Oil and Gas Pipelining

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An Anniversary and a Look Into the Future

This issue of *The Petroleum Engineer* commemorates its 25th Anniversary. Custom dictates that upon reaching certain milestones a person or business concern pause and take stock of accomplishments. This we have done to a degree but we have gone further. Admittedly, an anniversary is of greatest interest to the one involved, of limited interest to others. So, in planning special articles that would best fit such an occasion, they have been designed not alone to present some of the highlights of past developments but to take a look into the future and prognosticate what is to come. We believe you will be interested in both aspects.

In reviewing the past, we are sure you will permit us the pardonable pride we take in pointing out that the engineering and technological development of the industry parallels closely the quarter century that is the history of *The Petroleum Engineer*. As pointed out elsewhere, the technical men were of limited number 25 years ago, their acceptance considerably less than universal. The years between have seen a complete change in attitude; have also seen a change from somewhat loose operating practices to scientific ones. The *Petroleum Engineer* was the first oil publication to disseminate information of an engineering-operating nature. It was founded for that purpose.

But one does not live in the past — the future is the important thing. With this in mind, the views of industry leaders were asked and freely given. What of the future in light of the past and present? What role, for instance, will atomic energy play in the world power picture? Will solar energy be an important factor? And will the two together lessen demand for petroleum?

What new refining processes seem indicated? What of aviation fuels? Would conversion of airplanes entirely to the use of jet power change the picture of internal-combustion engine fuel production?

There can be no question that wells will be drilled increasingly deeper, and this will involve certain problems. Among the most vital are lost circulation and crooked holes. Penetration rates need further improving. Marked changes in exploratory drilling seem imminent. Offshore drilling methods and equipment are in their comparative infancy.

A high percentage of what is now considered unproducible crude oil ultimately will be recovered. What ideas and methods are in the offing that will make this possible?

Will it ever be possible for a dispatcher and two or three assistants to operate a complete pipe line system from a central point with only supervisory and maintenance personnel elsewhere on the system? Which way will station design go? To more compact or to larger installations? How large will line pipe eventually be for greatest efficiency?

These are all provocative subjects. They are only a small part, however, of those discussed in the articles in this issue labeled "Anniversary Issue — Forecast." We are sure you will be more than interested in taking a look into the future with some of the best forward looking minds in the industry.

FRANK H. LOVE.

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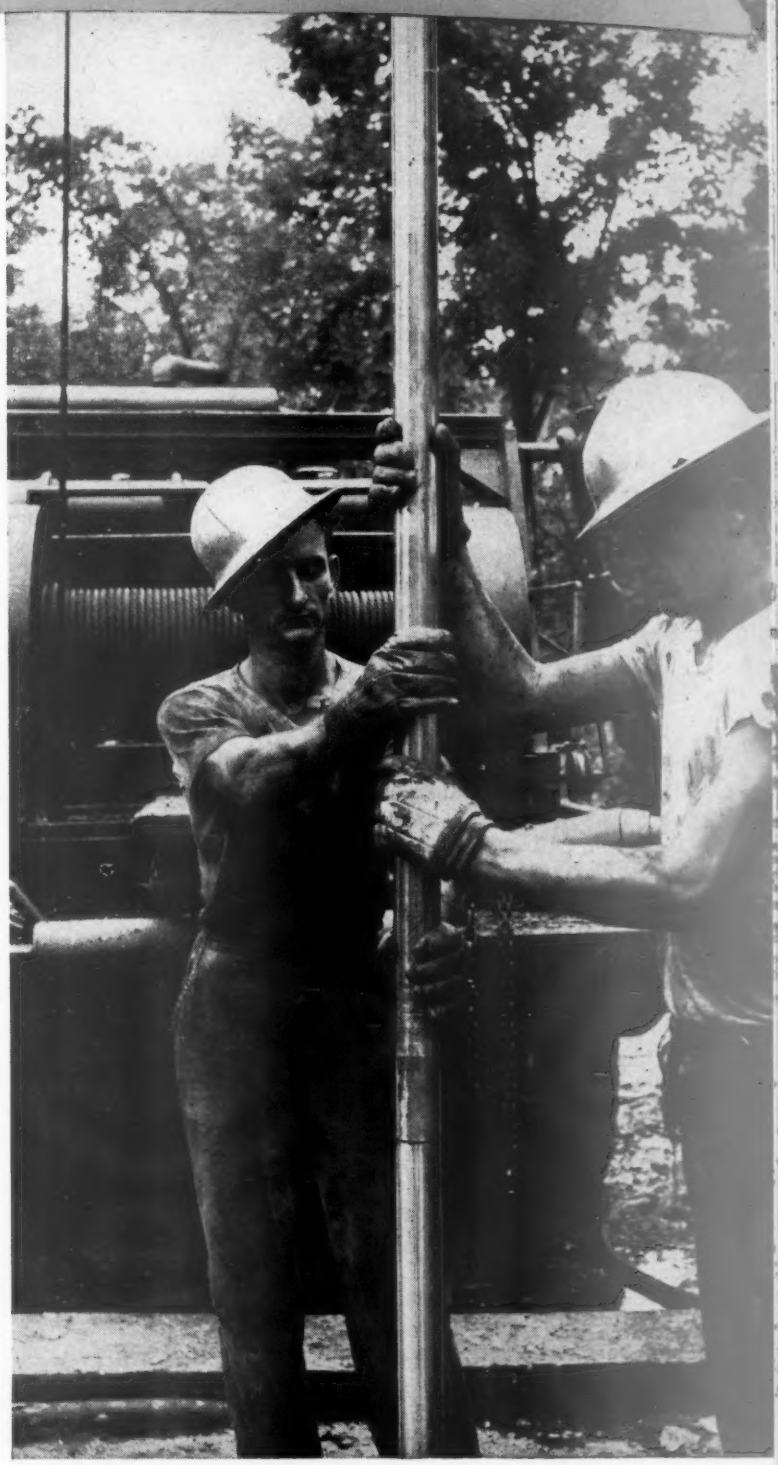

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HIGHLIGHTS ★ ★ ★

Digest of News and Comment

D&D Officers Elected

Sybil Sureck, vice president and secretary of Union Oil Company of Oklahoma, has been elected president of the Association of Desk and Derrick Clubs of North America. Other officers elected were: Edna Hurry, New York City, first vice president; Minetta Miller, Denver, Colorado, second vice president; Frankie Frensley, Dallas, Texas, treasurer, and Nelle Barclay, Oklahoma City, Oklahoma, association secretary.

Desk and Derrick contest winners were: Carol Eberhart, Desk and Derrick New Yorker, New York, writing division; Francess Routh, Draw Works, Corpus Christi, Texas, art division, and Margaret Golian, editor Gas Lights, Cleveland, Ohio, bulletin division.

★ ★ ★

Tidelands Leases Offered

The federal government has offered 199 tracts of submerged lands off the coast of Louisiana for oil and gas leasing. A minimum bonus bid of $15 an acre will be required. There are 748,000 acres in the tracts.

★ ★ ★

Lube Oil Suit Filed

The Barkow Petroleum Company has filed a suit in the district court in Washington, District of Columbia, asking the court to direct the Commissioner of Internal Revenue to collect the 6 cents per gallon excise tax on lubricating oil made by reclaimers who manufacture lubricating oil by reprocessing crankcase drainings. The action has been brought in an attempt to get the Bureau of Internal Revenue to apply the tax fairly to all competing manufacturers.

★ ★ ★

Film to Be Premiered

National public premiere of the new color motion picture, "The Story of Colonel Drake," will take place Thursday, October 7, in Titusville, Pennsylvania, near the site of the world's first well drilled for oil. Premiere is expected to attract nationwide attention since it will serve as a kickoff for Oil Progress Week, October 11-16. More than 450 prints have been sold to oil companies and others following private previews. Film was produced by the American Petroleum Institute.

Solar Energy the Answer?

The United Nations Conference on Population, recently held in Rome, was told that mankind should look to solar energy rather than atomic power as a future substitute for natural resources. It was stated that the amount of sunshine that falls on an acre of land should produce enough power for the needs of one man and the amount falling on the average sized house enough to provide all electrical needs of a family.

★ ★ ★

NPC Appoints Study Group

The National Petroleum Council has appointed a committee to make a new study of U. S. productive capacity as of July 1. The study will cover individual Petroleum Administration for defense districts, and will provide data on availability of crude oils, natural gas liquids, and all oils, as well as on production and reserve producing capacity.

★ ★ ★

Oil Campaign Begun

A campaign to broaden the use of oil in heating medium and low-priced homes will be undertaken by a national oil heat council. Campaign will be set up on a three-year basis and will include nationwide and local advertising, cooperating with home builders and other activities.

★ ★ ★

Iranian Oil Pact Signed

The Iranian oil pact has been signed by Iran's finance minister Ali Amini, chief negotiator for Iran, and Howard Page, chief negotiator for the consortium of eight foreign companies. The Majis, lower house of the Iranian parliament, is expected to approve the agreement.

★ ★ ★

TIPRO Asks Hearing

The Texas Independent Producers and Royalty Owners Association has made a formal request to be heard by President Eisenhower's cabinet committee on fuels and energy resources. TIPRO president, Jack Woodard, also asked that a representative of the association be appointed to act in an advisory capacity with the committee.

Deep Rock Sale Aproved

Deep Rock Oil Corporation stockholders have voted to accept an offer by General American Oil Company of Texas of $27,000,000 for certain of Deep Rock's properties. Vote was a formal endorsement of action taken in July by the board of directors.

★ ★ ★

Import Plans Halted

A report from Mexico City says that plans to import natural gas from Mexico into the U. S. have reached an impasse in the governmental agencies. The economy ministry says that Mexico's needs should be met before gas is sold abroad. Pemex, the government oil subsidy, wants to sell to any purchaser available.

★ ★ ★

Esso Plans Oil Storage

A slate quarry, with an estimated capacity of 1,000,000 bbl of oil, will be used by Esso Standard Oil Company to store heating oil to meet demand during the winter months. Oil will be moved to pit through a 65-mile pipe line from Esso's Bayway refinery in Linden, New Jersey. This is the first experiment in the U. S. for storage of oil. It is being used successfully in Sweden for the storage of heavy fuel oils used by ships and industry.

★ ★ ★

Protest Line Conversion

The Federal Power Commission has been petitioned by four coal groups to intervene in the application of Texas Eastern Transmission Corporation to convert the "Little Big Inch" back from gas to oil product service. Petitioners said that conversion would create additional competition causing loss in revenue and wages and may cause serious and permanent unemployment.

★ ★ ★

File Gas Applications

Phillips Petroleum Company has filed with the Federal Power Commission 46 applications for approval of gas supply contracts under order No. 174-A. Phillips is the first large producer to file under the new order. Less than 20 producers out of some 4100 estimated to be covered have filed so far, according to FPC officials.

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1 Photo showing Peerless Line Separators at Pipeline Station in Oklahoma.

2 Peerless Horizontal Separator handling 240,000,000 cu. ft. per day, while removing condensed liquid from cooling tower, at plant in California.

3 Two Peerless Vertical Scrubbers at a power plant in South Texas, each handling 50,000,000 cu. ft. of gas per day.

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Oil Purchase Plan Changed

The "Buy American Act" exemption on petroleum products purchased for federal agencies has been reduced to the East Coast by the General Services Administration. Previously all petroleum products have been exempted from the act. Edmund F. Mansure, head of GSA, said that more than half of the products of East Coast refineries are produced from foreign crude and to apply the act in that area would be unfair to refiners and distributors in other areas.

★ ★ ★

INGAA Elects Officers

John F. Merriam, president of Northern Natural Gas Company has been elected president of the Independent Natural Gas Association of America. He succeeeds C. P. Rather, president of Southern Natural Gas Company. Other officers elected were: J. J. Hedrick, Natural Gas Pipeline Company of America, first vice president; Glenn W. Clark, Cities Service Gas Company, second vice president, and Fred W. Peters, Oklahoma Natural Gas Company, treasurer.

★ ★ ★

Predict Oil Demand Hike

The Independent Petroleum Association of America has predicted an increase in demand for crude petroleum and its products for the next 3 months. IPAA forecast production of 6,340,000 bbl of crude daily.

★ ★ ★

Want Faster Deliveries

The steel industry reports that orders for seamless tubing and drilling equipment are not coming in as fast as expected. Oil men are said to be demanding 30 days delivery instead of waiting for 6 months. Steelmen say that the lag is because tubing and supplies are more plentiful and foreign companies have increased their business.

★ ★ ★

Asks Action on Gas Law

Congressional action has been called for by The Independent Natural Gas Association of America, to strip the FPC of its power to regulate all sales of natural gas in interstate commerce. Resolution was approved by more than 400 natural gas executives at the annual meeting of the association.

Texas Allowable Cut

Texas' October oil allowable has been set at 2,788,141 bbl a day. This is a cut back of 59,138 bbl from the September allowable of 2,847,279 bbl a day. Producers had asked the commission not to make further cuts in the allowable.

★ ★ ★

Export Controls Eased

Export controls on crude oil, gas oil and distillate, fuel oil, residual fuel oil, microcrystalline wax, and petroleum coke have been eased by the U.S. Department of Commerce. No licenses will be required for such shipments except to Russia and its satellites and allies.

★ ★ ★

Bolivian Strike Reported

The Bolivian government has reported that Glenn H. McCarthy has brought in the first oil well in the Los Monos concession. First well, in the 970,000-acre concession, was brought in last April as a gas-distillate. Well, on a 24-hour test, flowed 112 bbl of 48 deg oil through ⅝-in. choke. Pay zone was in the Devonian sand between 3210 and 3250 ft. Gas-oil ratio was 800-1.

Well also flowed an estimated 47,000,000 cu ft of gas from 3500 ft. This zone was reported to be plugged.

★ ★ ★

Houston Show — Not Tulsa

The next International Petroleum Exposition in Tulsa will probably be held in 1957 or 1958, according to William B. Way, general manager, who said that the Tulsa show is in no way connected with the "International Oil Exposition" announced to be held in Houston in 1955. Way said that he had received inquiries from Tulsa show exhibitors about the "International Oil Exposition."

★ ★ ★

Turbine for Autos

The Austin Motor Company, a British automobile company, has announced that it has overcome one of the main obstacles to gas-turbine automobile motors by successfully fitting a car with a heat exchanger turbine. The fitting of a heat exchanger in the exhaust system utilizes waste gases and lowers fuel consumption.

Shale Committee Formed

A committee to advise the Interior Department on continued operation of the government's oil shale plant at Rifle, Colorado, has been appointed by the National Petroleum Council. Committee will review recommendations that work at Rifle should cease unless there is a contribution by industry under a cooperative agreement.

★ ★ ★

Weather Control Asked

Improved weather forecasting services in the Gulf of Mexico, by the federal government, have been asked by tidelands oil and gas operators. Other projects launched by the operators have in mind to: Avoid unwarranted pollution lawsuits, safeguard personnel on drilling platforms, and cut cost of equipping and using tideland vessels.

★ ★ ★

Russian Refinery Explodes

An explosion at a Stalingrad oil refinery that killed "hundreds" has been reported by the German newspaper Die Wilt. Victims are said to include L. Safrasiyan, deputy minister for the Soviet oil industry, and A. N. Navulin, chief engineer of the ministry.

★ ★ ★

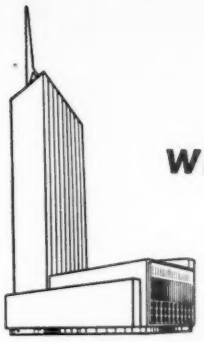
Union Merger Approved

The CIO United Gas, Coke and Chemical workers have voted to merge with the CIO Oil Workers International. The oil workers are scheduled to vote on the merger at its national convention November 15 in Cleveland, Ohio. The oil union has already adopted a resolution calling for the merger.

★ ★ ★

Coal Against Gas Order

Recommendations presented to a staff meeting of the Department of Interior interdepartmental soft coal committee show that the coal industry is in favor of a reversal of the recent law regulating gas sales by independent producers and gatherers. The recommendations were presented by the "natural gas subcommittee of the Bituminous Coal Industry Committee." The committee also recommended that the FPC have broader powers over exports and imports of natural gas and have authority to fix "minimum" rates.



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PETROLIC PERSONALITIES

DICK SNEDDON

ABOUT PEOPLE IN FAR AWAY PLACES

We have recently been running into all sorts of interesting people from different parts of the world and find them without exception excellent company. For example, just a few days ago we had the pleasure of a brief moment or two with Bill Lance, drilling superintendent for Iraq Petroleum Company, over in Dukhan, now home on leave for a month or two. Bill was born in Moody, Texas, and has worked widely in the Texas and California oilfields, besides putting in considerable foreign service in Brazil, Ecuador, Peru, and other far-flung areas. We understand that his favorite pasttime is a unique game, sometimes known as "spit in the "sink," at which he has garnered more shekels than the Infernal Collector of Revenue.

About the same time we encountered Jack Stovall, toolpusher for Drillex over in Iran. Jack is a native of Arkansas, but spent most of his early life in Texas, around the Electra and Burkburnett fields. He has also traveled extensively, having put in a lengthy stint for Aramco in Saudi Arabia. On his way home this trip, he took advantage of the occasion to do a pretty thorough trip of Europe and had more fun than the proverbial picnic. Jack loves big game fishing and has in his time wrestled with practically everything that swims and a lot of things that don't swim. He claims to have landed at various times, sword fish steaks, fillet of sea bass, tuna **on casserole,** broiled halibut, and even oysters on the half shell.

A WHINGDING FOR JOE TAYLOR

Fred Currie, the Copperweld prexy, and one of the industry's most generous hosts, staged a snug little party at the Los Angeles Petroleum Club a short time ago for the noted New Yorker, Joe Taylor, retired director of purchasers for Socony-Vacuum Oil Company. Joe is unquestionably one of the best known and most liked purchasing executives in the country and his acquaintance reaches deeply into the operational as well as the executive levels of the oil industry. Present to pay their respects to the guest of honor were Monte Lindmoe, executive vice president of Southwest Welding; Paul Whiteley, purchasing agent for General Petroleum Corporation; Al Dragge, Pacific Coast manager for A. O. Smith; Hal Davis, the Meyer Drum representative; Claude Lane, Standard of Cal's purchasing chief from San Francisco, and his Los Angeles prototype, C. H. "Tut" Tuttle; Jack Bryson, young attorney from Montreal, Canada, and Charlie Perkins, Union Oil Company's manager of purchases. It was a very nice affair at which high tribute was paid Joe Taylor for his long years of guiding and directing bewildered out-of-towners, on their initial visits to the bewildering city of New Amsterdam.

WE GREET DISTINGUISHED CUBANS

Another pair of distinguished folk who have been observed foraging about the west coast looking over the petrolic scene in recent days, are Ingenieros Jorge Seiglie and Cesar Rodriguez, engineers with the Comision de Fomento Nacional de Cuba. These gentlemen have been sent to California to familiarize themselves with petroleum operations as they are there conducted.

We found them under the immediate tutelage of John Flanagan of Johnston Testers Inc., the No. 1 Nomad out this way, and knowing John as we do, we can assure the visitors that they are in excellent hands. John has for some years been doing a fine job as mentor to hundreds of visitors from other lands and he is ideally equipped both by appearance, and comportment to make a favorable impression anywhere.

HARVARD ALUMNI STILL GROWING

It was also our privilege not too long ago to meet a pleasant mannered chap from Seminole, Texas, who is now operating very successfully up in the vicinity of Wyoming. His name is Dave Mills and he happens to be a good friend of our own good friend, Bill Thornbury, the eminent California oil producer and domino sharpie. Dave is a graduate of Washington University and started his oil career in 1938 in his father's concern, Mills Oil Company of Shelby, Montana. After the war he took over on his own, doing development work in Texas, New Mexico, and Wyoming, principally the latter. In his moments of relaxation, Dave enjoys almost any kind of fishing or hunting and his favorite haunt is Jackson Hole up yonder in Wyoming.

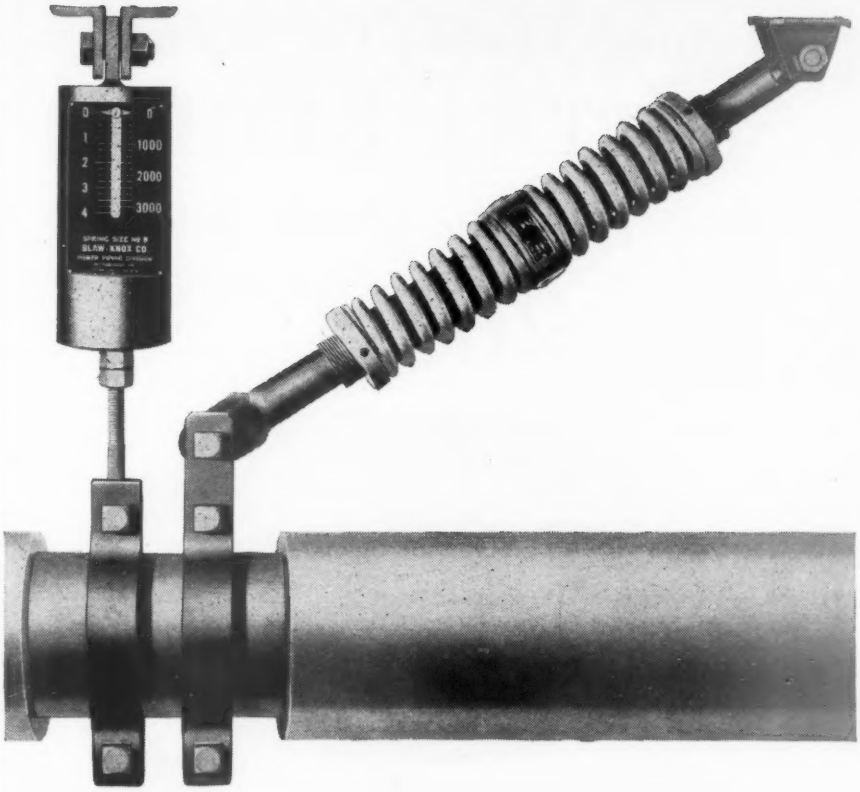
By way of last minute roundup, we hear tell that Jim Hughes, the well known Lane-Wells higher-up, will be attending that business executive course at Harvard for the next two months more or less, and we shall be watching to see if he comes back home with a red blazer and a broad "a". Among others we can think of who are alumni of that class are: Ed Hamner, Mort Higgs, John Neale, John Kerfoot, Roy Johnson, and Paul Huggins. And, it has nothing to do with the subject, but the public stenographer who does our typing when it really has to be good, has a sign on her desk that gives us a chuckle every time we see it. The legend it carries is, "Before You Louse Things Up—THIMK!" Wherewith we leave you to your own devices. Remember, one man's junk is another man's antique.

Meetings

Oct. 7-8—**California Natural Gasoline Association,** annual, Ambassador Hotel, Los Angeles, California.
Oct. 10-16—**Oil Progress Week.**
Oct. 11-13—**American Association of Oil Well Drilling Contractors,** annual, Biltmore Hotel, Los Angeles, California.
Oct. 11-13—**American Gas Association,** annual, Atlantic City, New Jersey.
Oct. 12-15—**National Chemical Exposition,** annual, Chicago Coliseum, Chicago, Illinois.
Oct. 13—**American Institute of Chemical Engineers,** New York section, Symposium, Hotel Statler, New York, New York.
Oct. 14-17—**Permian Basin Oil Show,** Odessa, Texas.
Oct. 17-20—**American Institute of Mining and Metallurgical Engineers,** petroleum division, Fall meeting, Plaza Hotel, San Antonio, Texas.
Oct. 18-22—**National Safety Congress and Exposition,** annual, Conrad Hilton, Morrison, Congress, LaSalle Hotels, Chicago, Illinois.
Oct. 21-22—**Western Petroleum Refiners Association,** regional, Garrett Hotel, El Dorado, Arkansas.
Oct. 21-23—**Rocky Mountain Oil and Gas Association,** annual, Cosmopolitan Hotel, Denver, Colorado.
Oct. 22-24—**The Golden Trend Oil Exposition,** sponsored by the Golden Trend Chapter, American Institute and Pauls Valley Chamber of Commerce, County Fair Buildings, Pauls Valley, Oklahoma.
Oct. 24-26—**Independent Petroleum Association of America,** annual, Mayo Hotel, Tulsa, Oklahoma.
Oct. 25-27—**National Lubricating Grease Institute,** annual, Mark Hopkins Hotel, San Francisco, California.
Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.
Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.
Oct. 29—**Natural Gasoline Association of America,** Southern regional, Blackstone Hotel, Tyler, Texas.
Nov. 1-3—**Geological Society of America,** annual, Statler Hotel, Los Angeles, California.
Nov. 1-5—**American Society for Metals,** national, Palmer House, Chicago, Illinois.
Nov. 3-5—**Gulf Coast Association of Geological Societies,** annual, Rice Hotel, Houston, Texas.
Nov. 4—**American Association of Oilwell Drilling Contractors,** annual South Louisiana Safety clinic, New Iberia, Louisiana.

NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.
Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.
Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.
Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.
Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.



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One sure way to cut your field erection costs is to use Blaw-Knox hangers and eliminators. Each is a complete packaged unit, ready to install. No expensive cutting, threading and assembling on the job. And you'll also save on engineering and specifying time.

Each Blaw-Knox functional spring hanger, rigid hanger assembly, overhead roller assembly, and vibration eliminator is designed for a specific purpose. Constructed to conform with the "code for pressure piping." Available in types and sizes to meet varying conditions.

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BLAW-KNOX COMPANY, Power Piping and Sprinkler Division, Pittsburgh 33, Pa.

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Complete line of functional spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated power piping systems for all pressures and temperatures.

United Towing Co. reports LATTICE BRAID* *outlasts* previous pump packings 26 to 1

*Registered Trademark. *Only* Garlock makes LATTICE BRAID rod and shaft packings.

United Towing Company of Wilmington, Cal. tried a number of packings on their rotary gear pumps handling *cold molasses* and operating at 120 p.s.i. In starting the pumps, the cold molasses would ruin these packings. In fact, no packing would last more than 8 to 10 hours. That is, until United Towing tried rugged LATTICE BRAID asbestos packing with wire insertion and wire corners. In actual running time, LATTICE BRAID has lasted for 260 hours—26 times longer than any previous packing.

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

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GARLOCK LATTICE BRAID PACKING

Nov. 4-5—**Society of Automotive Engineers,** national fuels and lubricants meeting, Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-11—**American Petroleum Institute,** annual, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 10—**American Petroleum Institute,** executive committee of board of directors, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 11-12—**American Association of Petroleum Geologists,** Pacific section annual, Biltmore Hotel, Los Angeles, California.

Nov. 15-17—**American Standards Association,** annual, Roosevelt Hotel, New York, New York.

Nov. 15-17—**National Conference on Standards,** annual, Roosevelt Hotel, New York, New York.

Nov. 17-18—**American Institute of Mechanical Engineers,** North Texas section, and **North Texas Oil and Gas Association,** production committee, symposium on secondary recovery, Wichita Falls, Texas.

Nov. 18—**National Industrial Conference Board,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 18-19—**Society of Exploration Geophysicists,** Midwestern division, annual, Adolphus Hotel, Dallas, Texas.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Nov. 30-Dec. 2—**Electronic Computer Clinic and International Automation Exposition,** 244th Regiment Armory, 14th St. between 6th and 7th Avenue, New York, New York. Address inquiries to Electronic Computer Clinic, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania.

Dec. 2-4—**Interstate Oil Compact Commission,** Winter meeting, Drake Hotel, Chicago, Illinois.

Dec. 2-7—**National Exposition of Power and Mechanical Engineering,** Commercial Museum, Philadelphia, Pennsylvania.

Dec. 3—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual, Statler Hotel, New York, New York.

1955

Jan. 10-14—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Michigan.

Jan. 17-19—**Pipe Line Contractors Association,** Statler Hotel, Los Angeles, California.

Jan. 24-27—**American Society of Heating and Ventilating Engineers,** annual, Philadelphia, Pennsylvania.

Jan. 27-28—**American Chemical Society,** Southeastern Texas section, symposium on hydrocarbon chemistry, Houston, Texas.

Feb. 10-12—**Institute of Radio Engineers Conference and Electronics Show,** Baker Hotel, Dallas, Texas.

Feb. 13-17, 1955—**American Institute of Mining and Metallurgical Engineers,** annual, Conrad Hilton Hotel, Chicago, Ill.

Feb. 25—**Natural Gasoline Association of America,** Permian Basin regional, Scharbauer Hotel, Midland, Texas.

March 9-11—**American Petroleum Institute,** Southwestern District, Division of Production, Jung Hotel, New Orleans, Louisiana.

March 20-23—**American Institute of Chemical Engineers,** Kentucky Hotel, Louisville, Kentucky.

April 13-15—**Natural Gasoline Association of America,** annual, Baker and Adolphus Hotels, Dallas, Texas.

April 19-21—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

June 6-15, 1955—**Fourth World Petroleum Congress,** Rome, Italy.

Sept. 12-16—**Instrument Society of America,** National Instrument conference and exhibit, Los Angeles, California.

Secondary Recovery Symposium Slated

A Secondary Recovery Symposium, sponsored by the North Texas section of AIME and the North Texas Oil and Gas Association has been scheduled for November 17-18 in Wichita Falls, Texas. The technical sessions will be held in the auditorium at Midwestern University, and the banquet will be in the University Center building.

David B. Meisenheimer, district petroleum engineer for The Texas Company, will deliver the initial address and outline the symposium.

Symposium committee members include E. Morris Seydell, Seydell Operating Company, chairman; Richard R. Darner, Wayne H. Hammon Company; Rollie Dobyns, Bureau of Mines; Roland Goudy, consulting engineer; Donald T. May, Ryder Scott Company; and Elmer T. Milz, Shell Oil Company.

The banquet will be held on Thursday night and will feature William J. Murray, Jr., Commissioner, Texas Railroad Commission, speaking on "Secondary Recovery and the Railroad Commission of Texas."

Speakers and their subjects on Wednesday, are:

L. L. Brundred, Brundred Enterprises—"Economics of Water Flooding"; W. L. Horner, vice president Core Laboratories, Inc.—"Evaluation of Reservoir Characteristics"; A. B. Dyes, Atlantic Refining Company—"Sweepout Patterns in Depleted and in Stratified Reservoirs"; R. C. Earlougher, Earlougher Engineering Company—"Water Source and Requirements"; John F. Buckwalter, Ryder Scott Company—"Water Flood Patterns and Injection Rates"; George L. Buckles, Buckles and Hostetler—"Well Completions for Water Flood Operations"; J. Wade Watkins, Bureau of Mines—"Design and Operation of Plants for the Preparation of Water for Injection into Oil Reservoirs"; and Paul D. Torrey, Orchem Corporation—"Preparation of Water for Injection into Oil Reservoirs."

On Thursday, November 18, the following program will be presented: J. W. W. Whitney, Jr., Magnolia Petroleum Company—"Magnolia West Burkburnett Waterflood Project"; Ray L. Freeborn, Continental Oil Company—"Gas Injection and Waterflood Performance Hildreth Unit Montague County, Texas"; and Rollie Dobyns, Bureau of Mines—"Waterflood Activity in KMA Field."

OPERATION BEST SILENCING!

Special Orders:

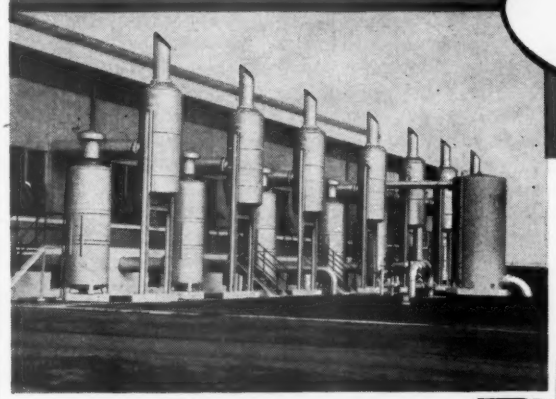
BURGESS-MANNING Exhaust and Intake

Snubbers installed for Tennessee

Gas Transmission Company

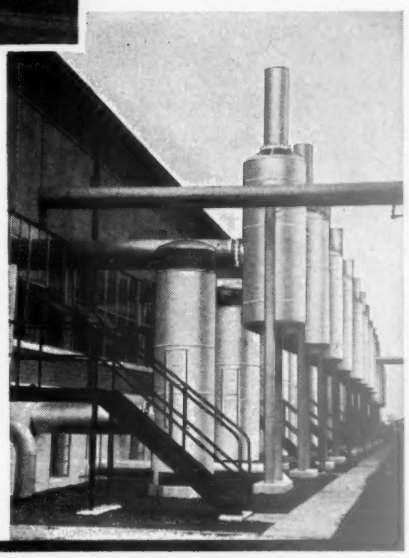
. . . engineered for this service.
. . . built to meet specific requirements.

OVER 100 SNUBBERS



Below: Exhaust snubbers and combination air filter snubbers engineered and built for four 1,600 h.p. and eight 2,000 h.p. gas engines at Station #1, Agua Dulce, Texas.

Above: Seven exhaust snubbers and seven combination air filter snubbers designed to meet the silencing requirements of seven 2,000 h.p. gas engines at Station #9, Bloomington, Texas.



Proper silencing is one of the keynotes of efficiency. That is the reason Tennessee Gas Transmission Company, operator of one of the major trunk line systems in the country, consulted Burgess-Manning Sound Engineers on their silencing requirements. Over one hundred snubbers were engineered and constructed by Burgess-Manning to eliminate the intake and exhaust noises at compressor stations along the Tennessee line.

For engineering data on your problem of noise control, call a Burgess-Manning Sound Engineer.

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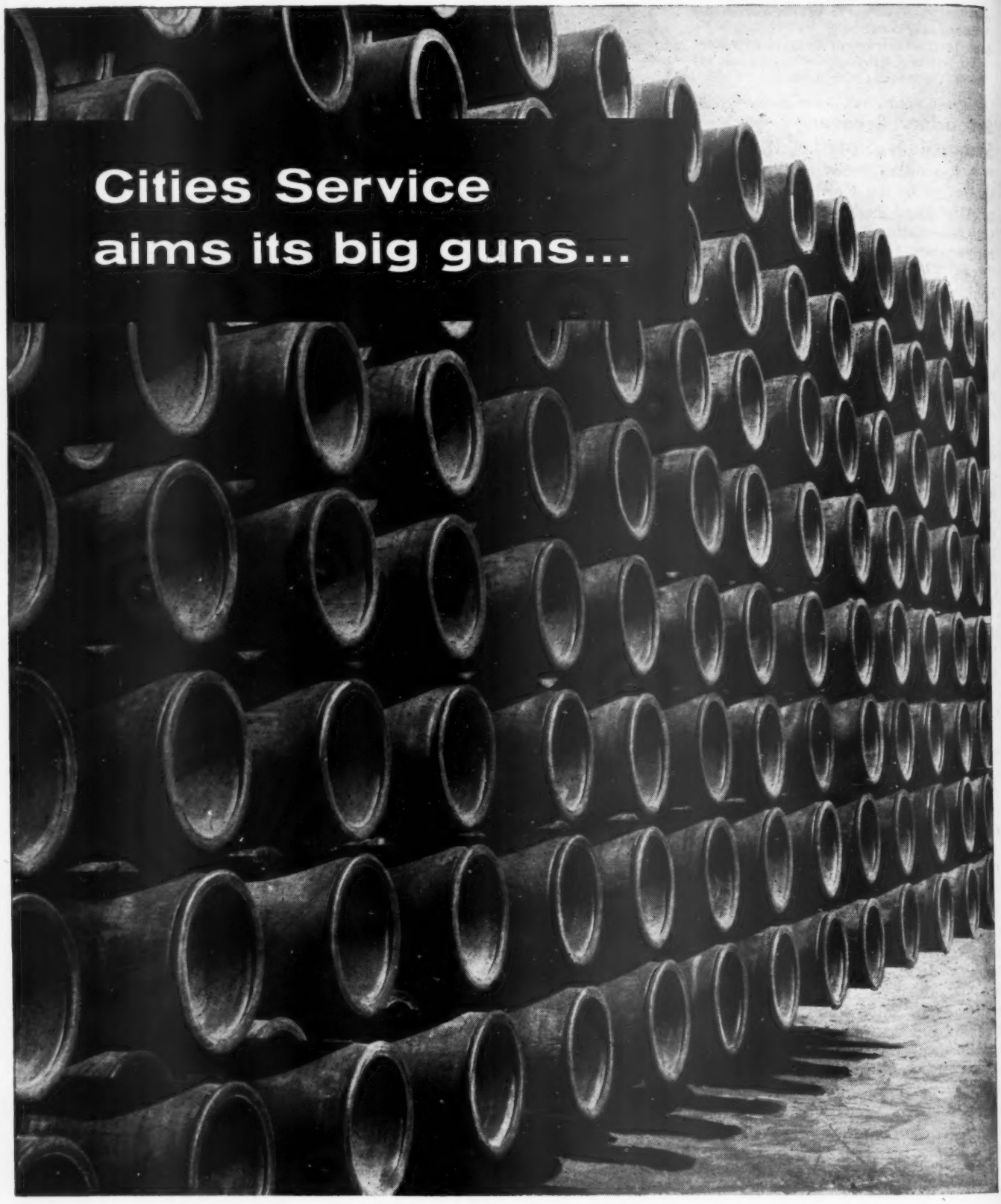
To obtain more information on products advertised see page E-57



Acres of casing are mobilized in readiness at a well site. Last year an average of 1⅓ producing wells were drilled every day by

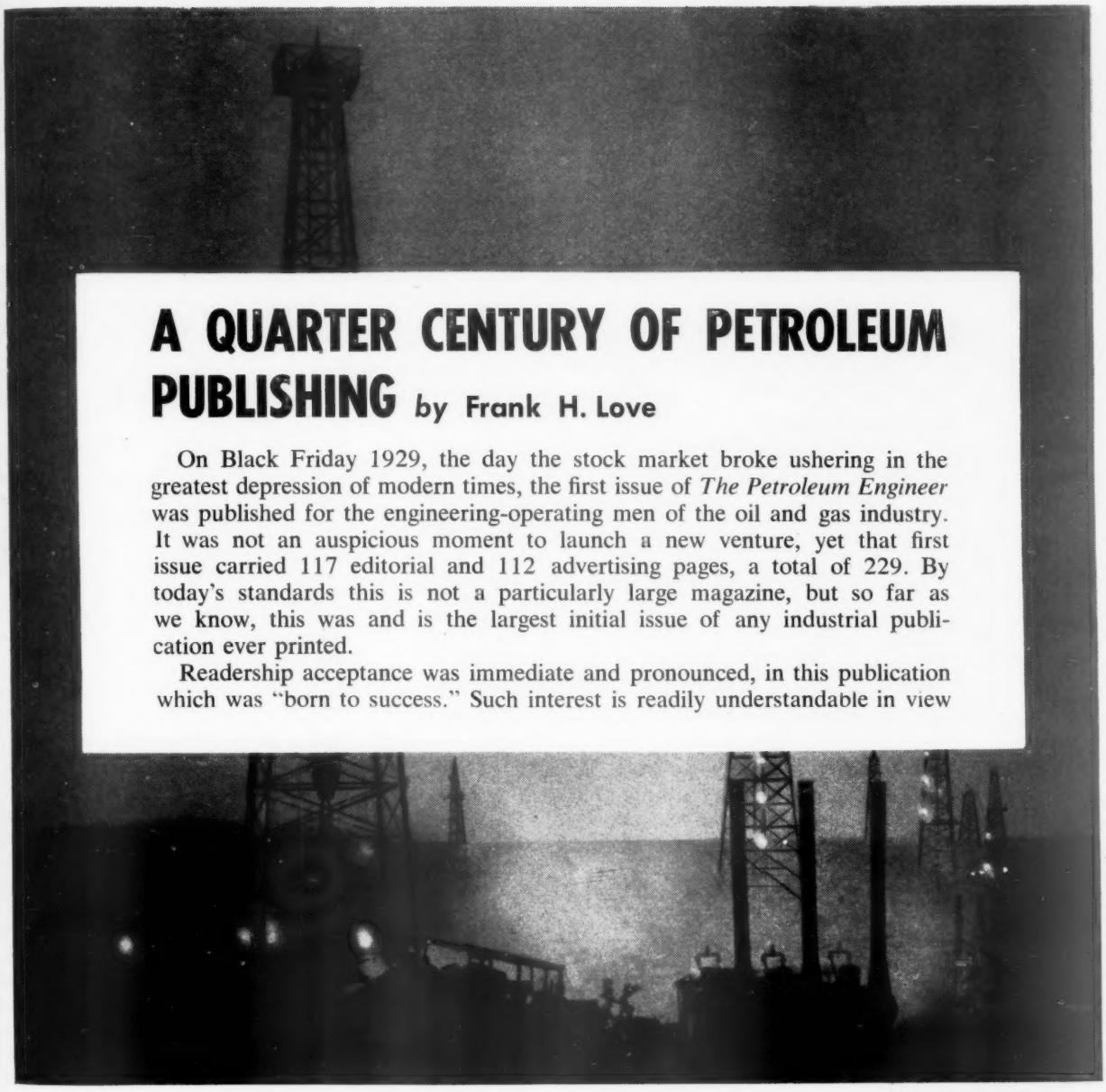
CITIES SERVICE

A Growth Company

THE Petroleum Engineer

ENGINEERING MAGAZINE OF THE OIL AND GAS INDUSTRY

Tulsa Oklahoma



A QUARTER CENTURY OF PETROLEUM PUBLISHING by Frank H. Love

On Black Friday 1929, the day the stock market broke ushering in the greatest depression of modern times, the first issue of *The Petroleum Engineer* was published for the engineering-operating men of the oil and gas industry. It was not an auspicious moment to launch a new venture, yet that first issue carried 117 editorial and 112 advertising pages, a total of 229. By today's standards this is not a particularly large magazine, but so far as we know, this was and is the largest initial issue of any industrial publication ever printed.

Readership acceptance was immediate and pronounced, in this publication which was "born to success." Such interest is readily understandable in view

EDITED AND CIRCULATED ONLY FOR THOSE ACTIVELY ENGAGED IN THE OPERATING DEPARTMENTS OF THE INDUSTRY

OCTOBER, 1929

of the very name and purpose of *The Petroleum Engineer* from its first conception.

A quarter of a century ago the engineer and technologist were only beginning to establish themselves as a vital part of this rapidly growing industry. The need to use more scientific means of finding, drilling, producing, refining, and transporting petroleum was beginning to be recognized, but the technical men were still a minority group, and many of the "oldtimers" who had come up "the hard way" were not ready to acknowledge they were at all necessary. That situation has changed today when, actually, practically all operating men are engineers, whether they obtained the necessary knowledge from books or entirely from experience in the field.

The early oil publications, likewise, were not fully cognizant of their responsibility and were confining their function primarily to dispensing news. The need was not yet realized for giving the engineering-technologist-operating men authentic and factual information on the latest developments in methods and equipment that would help them solve their daily problems, and aid them in doing a more efficient, economical, and intelligent job.

The men who founded *The Petroleum Engineer* foresaw this need, and recognized that the trend would continue more and more along engineering and technical lines. Twenty-five years later it is gratifying, of course, to know that the petroleum industry has developed along the lines predicted and has borne out the soundness of *The Petroleum Engineer's* original idea. As a prominent member of the industry recently expressed the matter: "*The Petroleum Engineer* is a name to which the industry has grown."

This editorial concept has remained correct and unchanged. There have been changes in types of technical personnel since earlier days. Engineers and technologists have become increasingly specialized, consequently there are now many kinds of engineers. This change, however, only means that the industry has become more complex and the problems more numerous, emphasizing that specialization in publications is essential to keep pace with the specialization within the industry. It was exactly such a consideration, as a matter of fact, that prompted *The Petroleum Engineer* in 1948 to initiate a selective publishing plan, the latest of many innovations throughout its history. Urged by readers to "give us a magazine that fits our particular needs," publication of four editions began at that time, covering "Exploration, Drilling and Producing," "Refining, Petrochemicals and Gas Processing," "Oil, Gas and Products Pipelining," and the three combined into a "Management Edition." This gives the reader an oportunity to select the editorial coverage he prefers. Attesting to the popularity of this plan, during the first six months following its introduction, PE doubled the biggest gain in paid circulation ever made.

Going back to earlier days, *The Petroleum Engineer* has the distinction of having introduced many other editorial firsts. One was an Engineering Fundamentals Department, whose purpose it was to present the fundamentals of refining, production, and pipe line practices for plant and field men who had not taken engineering courses, or for those who wished to broaden their knowledge of a branch of the industry in which they were not actively engaged. These articles began in 1933.

The Petroleum Engineer's Continuous Tables, another first, saw the light of day in June, 1937, so with this issue (October, 1954) they are being published for the 206th time. The purpose of the tables is to save time and effort for the engineer or other technician, and to assist the practical plant or field worker in solving problems encountered in his work.

Again, *The Petroleum Engineer* is the only oil publication that provides a decimal method for filing articles. Index numbers first appeared on PE articles in the January, 1939, issue, although they previously had been used to index "Continuous Tables." PE articles can thus conveniently be filed along with other industry literature, including association papers, reports, pamphlets, clippings, maps, drawings, notes, etc.

Other innovations of the last several years have included a comprehensive "Technical Forum" in the Refining and Petrochemical Edition. Acting as a special board to answer technical questions from *Petroleum Engineer* readers are twenty outstanding authorities in the industry. Another feature of this edition is a special department on "Analytical Procedures," another instance where *The Petroleum Engineer* saw the need to fill a specific void and was first to give it to its readers.

Evidence of continuing alertness to the needs of the industry is the latest addition to this long list of editorial trail-blazers — the series "Fundamentals of Rotary Drilling," which began in the June issue of this year. The purpose of this series is to provide in printed and handy form the basic principles of rotary drilling for immediate use and to serve as reference material. Fifty-five subjects will be treated in all, each forming a separate article, and three or four articles are included in each issue of the magazine. Hundreds of prominent persons in the industry assisted in outlining the subjects that should be covered, and an outstanding authority is writing each chapter.

These are a few of the innovations,

PETROLEUM ENGINEER FIRSTS

First petroleum publication to devote editorial coverage exclusively to engineering and method-type articles.

First petroleum publication to run a department on Engineering Fundamentals.

First petroleum publication to include a department on Engineering Tables.

First to number articles by a Decimal System for filing purposes.

First petroleum publication to carry a Rotogravure Pictorial Section.

First to publish a yearly comprehensive analysis of oil company financial statements.

First to compile international statistics on deep wells.

First to publish specialized magazines for all branches of the oil industry.

First to publish an article on electric well logging.

First to publish an article on gun perforation.

First to publish an article on cycling.

First to publish an article on pressure maintenance.

First to publish an article on straight-hole drilling.

First to publish an article on cathodic protection of pipe lines.

First to give general coverage of pipe line construction projects.

First to publish an article on automatic control of pipe line stations.

First to publish a complete, fully illustrated story of a cat-cracker turnaround.

First to institute a special department on Analytical Procedures.

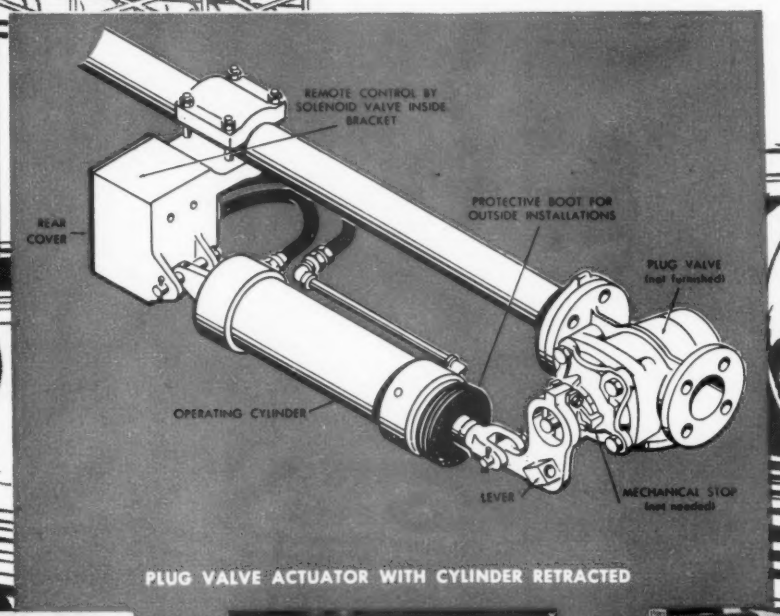
First to run a handbook series on the fundamentals of rotary drilling.

First to break down circulation by titles.

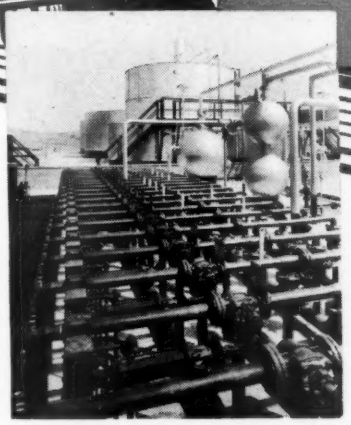
XUM

Pantex

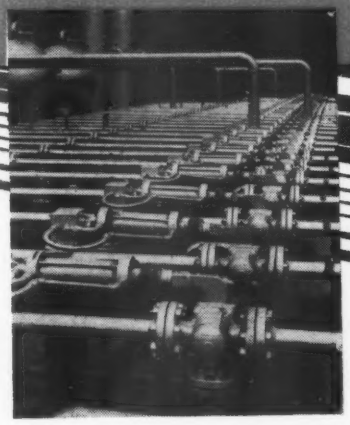
PLUG VALVE ACTUATORS



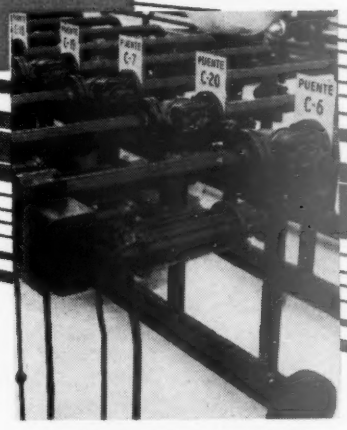
PLUG VALVE ACTUATOR WITH CYLINDER RETRACTED



20 unit farm showing assembly of Pantex Plug Valve Actuators in service.



30 unit farm installation in leading California refinery.



40 unit trap farm of Shell Oil Co. in Brea Canyon Field in California.

. . . tried, tested and approved—

Wherever wrench-operated plug valves are periodically turned "on" and "off," whether it be on gathering lines, farm lines, or in the refinery or the refinery's power plant, there's a good chance the Pantex Plug Valve Actuator can do it better, easier, and more economically.

Designed, engineered, and shipped as a complete, packaged unit ready for quick, easy installation, the Pantex Plug Valve Actuator has a solenoid valve as an integral part of the unit for remote or automatic action. Can also be supplied for hand valve operation. Pneumatically powered, these actuators are available for *all* sizes of wrench-operated plug valves.

If your processes require actuated plug valves, why not check this the most modern, thoroughly tested and accepted assembly in the industry. See your Distributor or write direct for Bulletin.

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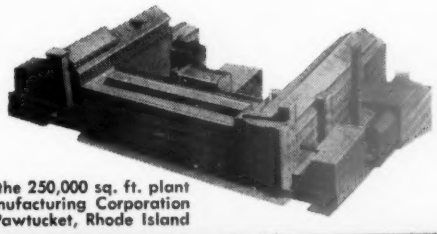
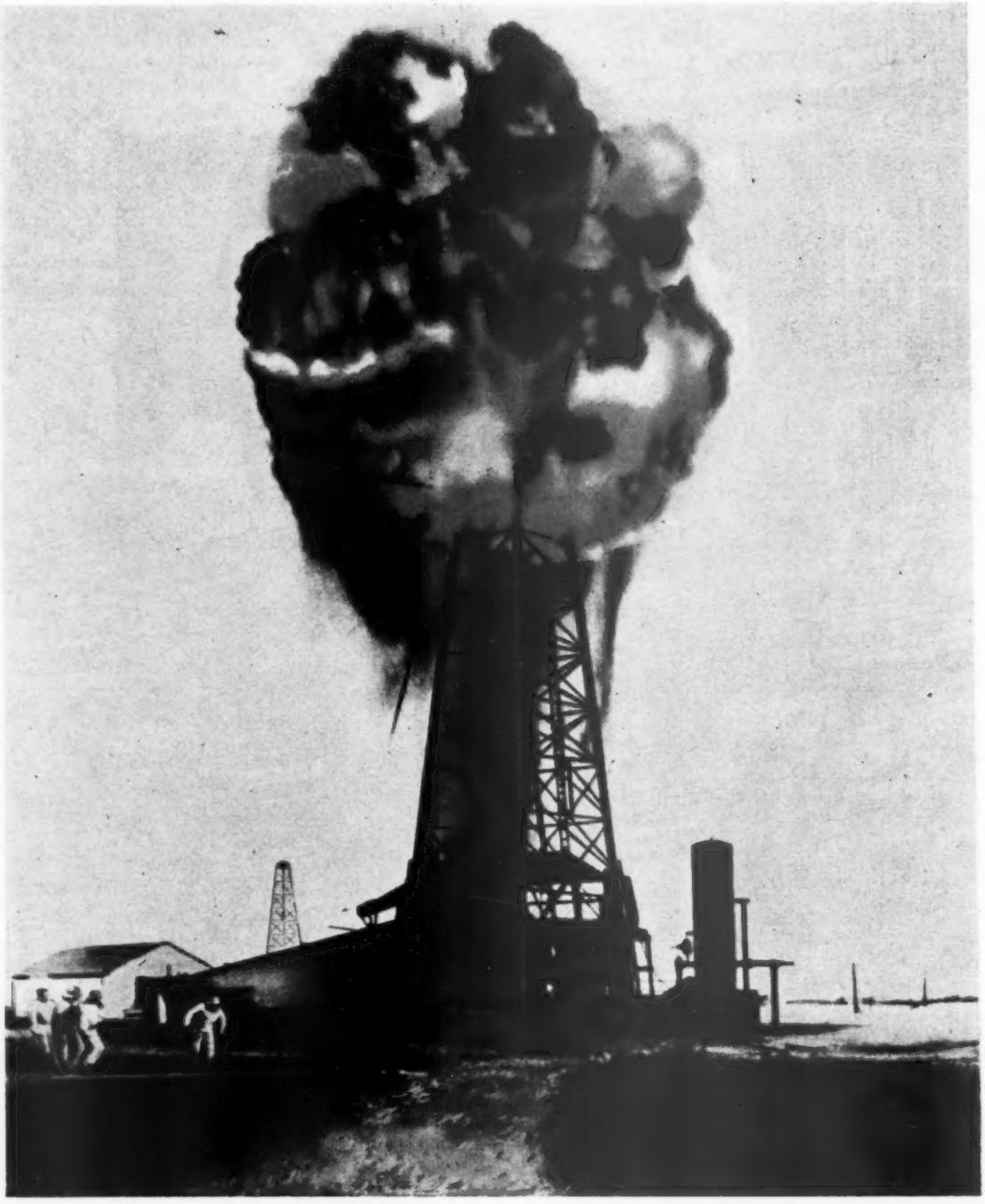


Photo of the 250,000 sq. ft. plant of Pantex Manufacturing Corporation at Pawtucket, Rhode Island

Remember This Picture?



AN interesting segment of *The Petroleum Engineer's* history is the famous photograph shown here. First published as a cover on the May, 1930, issue, by popular request it went through four printings, totaling many thousands of copies. Distribution was so wide, in fact, that it could be found all the way from a bunkhouse in the Raccoon Bend field to 26 Broadway, New York City.

This unusual picture was taken in April, 1930, in Ector County, Texas, of a well owned by Skelly Oil Company and Amerada Petroleum Corporation. The well was shot to increase production and, anticipating a gusher (wells were allowed to blow over the top of the derrick in those days), the photographer had his equipment set up to get the picture. When rocks thrown out by the shot came in contact with the crown block, creating a spark and igniting the oil and gas, the photographer was so frightened by the explosion that he impulsively squeezed the bulb and made this picture possible, because a few moments later the entire derrick was in flames.

GUARD AGAINST DOWN TIME WHEN PRESSURES ARE UP

With Watson-Stillman Forged Steel Fittings . . .

The high cost of down time in today's high pressure processing and power plants demands careful selection of piping materials. This goes *double* for the fittings.

WATSON-STILLMAN FORGED STEEL FITTINGS give you maximum protection against high pressure, heat, corrosion, shock and vibration —elements often responsible for piping failures.

All W-S Carbon Steel Fittings are drop forged to produce the well-known forged-fiber structure with exceptionally high tensile and impact strength. They're designed for high strength, too, with extra heavy walls where you need them. And they're precision machined for perfect alignment.

Watson-Stillman Fittings are also available in forged stainless and alloy steels for exceptional service at high and low temperatures and for maximum resistance to corrosion.

For strong, tough, trouble-free joints—for safe, dependable operation of your piping system—specify W-S Forged Steel Fittings. Available in sizes ⅛" to 4" in both SCREW-END and SOCKET-WELDING types. Write for information today.

Sold Through Leading Distributors

WATSON-STILLMAN FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

Roselle, New Jersey

2

XUM

but the number is so great that a discussion of each would become cumbersome. Consequently, they are enumerated in an accompanying box. It seems appropriate, however, to mention two others specifically. These are the yearly compilation of international statistics on deep wells, which has come to be looked upon as authoritative on the subject; and the comprehensive analysis of oil company financial statements, which appears twice yearly.

Acceptance of *The Petroleum Engineer's* policies and accomplishments, as outlined here, can be gauged in several ways. There is the matter of circulation growth, for instance, which now is near 25,000. Of this total, 87 per cent are engineering-operating men, a greater percentage than any other petroleum magazine, weekly or monthly. Further, the Audit Bureau of Circulations statement shows a renewal percentage of 75.67 per cent, which places PE in the upper bracket among industrial magazines and is especially remarkable in view of the mobility of oil men.

During the last twenty-five years The PE has maintained a foresighted and practical publication for engineering-operating men. During the next twenty-five years we shall continue this progressive attitude, ever searching for new and better ways to give engineering-operating men information in terms of their own interests.

Magazine's Founders

The men who founded *The Petroleum Engineer* were Clarence Morris, T. J . Crowley, W. T. Bryan, and J. L. Dwyer.

Morris, the first president, was a civil engineer and advertising salesman in his earlier years. His first connection with oil publishing was in 1916 with the *Oil City Derrick*. Later he became a member of the advertising staff of the *Oil and Gas Journal,* subsequently becoming its advertising manager, a post he retained until the founding of *The Petroleum Engineer.*

T. J. Crowley, the first vice president, gained his early experience in the oil industry on cable tool rigs in Oklahoma. That was in 1917. After serving in the Navy during the First World War, he became affiliated with the *Oil Trade Journal* in New York City. He joined the *Oil and Gas Journal* in 1923 and served as mid-continent advertising representative until 1929, when he helped organize *The Petroleum Engineer.* In 1940 he assumed the post of advertising manager in addition to his duties as vice president, and became president in May, 1953.

W. T. Bryan was born into a newspaper family. Like his father before him, he has spent his entire business life in the newspaper and magazine field, employed by publications in the oil areas of Pennsylvania, Ohio, Oklahoma, and Texas. These affiliations followed attendance at the University of Michigan, and were the *Bradford Era, Toledo Times, Bowling Green Ohio Sentinel-Tribune, Oil and Gas Journal* and finally *The Petroleum Engineer.* He entered the employ of the Journal in 1917 in the business office and within a few years became its secretary-treasurer, occupying that post, as well as that of business manager, when he resigned in 1929 to become one of the founders and secretary-treasurer of *The Petroleum Engineer.* In 1940 he was made general manager of the latter publication, the position he now holds.

The first editor was J. L. Dwyer. He had been Oklahoma and Kansas editor for the *Oil and Gas Journal* before becoming editor and vice president of *The Petroleum Engineer.* Earlier he had been an independent oil operator in Oklahoma. In 1933 he resigned to become associated with the American Petroleum Institute in New York.

Among the early employees were W. L. Love, K. C. Sclater, and Frank H. Love.

W. L. Love's publication experience dated back to 1924 when he was with the Barrick Publishing Company in Kansas City, Missouri. In 1927 he went with the *Oil and Gas Journal* in Tulsa, Oklahoma. His first connection with *The Petroleum Engineer* was as advertising manager. He became a vice president in 1934 and was elected president in 1940.

K. C. Sclater, educated in Glasgow, Scotland, joined the Burmah Oil Company in 1907, and for nine years was stationed in Burmah. Entered the University of California in 1916, and was graduated with a BS degree in petroleum engineering in 1921. Followed practical oilfield work, when in 1925 he was appointed to the U. S. Bureau of Mines staff at Bartlesville, Oklahoma. In 1926 he left the Bureau to become chief petroleum engineer of the Marland Oil Company. He left Marland in December, 1928, and engaged in private consulting work until he joined *The Petroleum Engineer* as oil and gas production editor in 1929. Became editor-in-chief in 1933 and later was made a vice president as well.

Frank Love, whose early newspaper training was with the Barrick Publishing Company, has been a member of *The Petroleum Engineer* staff since 1931, as associate editor, managing editor, editor of the Oil and Gas Pipelining edition, and presently as editor-in-chief. * * *

What Were the Problems in 1929?

The articles contained in the early issues of The Petroleum Engineer were written in large measure by men actively engaged in the oil and gas industry, a practice that also exists today. They wrote about problems they themselves had encountered and told how they had been solved. It is interesting to note what some of these problems were. Crooked holes were giving trouble to the drilling people, and after thorough study the consensus seemed to be that too much weight on the bit was the cause. Control of water-cement ratios in oilwell cementing was another important subject, as was means of maintaining low operating and lifting costs necessitated by low crude prices.

Steam engines were still being used in some pipe line stations, but even at that time they were somewhat out of date. And this statement is found in an article about a station in Oklahoma: "Evidence of the march of progress is found at this station where an electric-driven plunger pump was added as an auxiliary unit." Common today, electricity was just coming into use on pipe line systems.

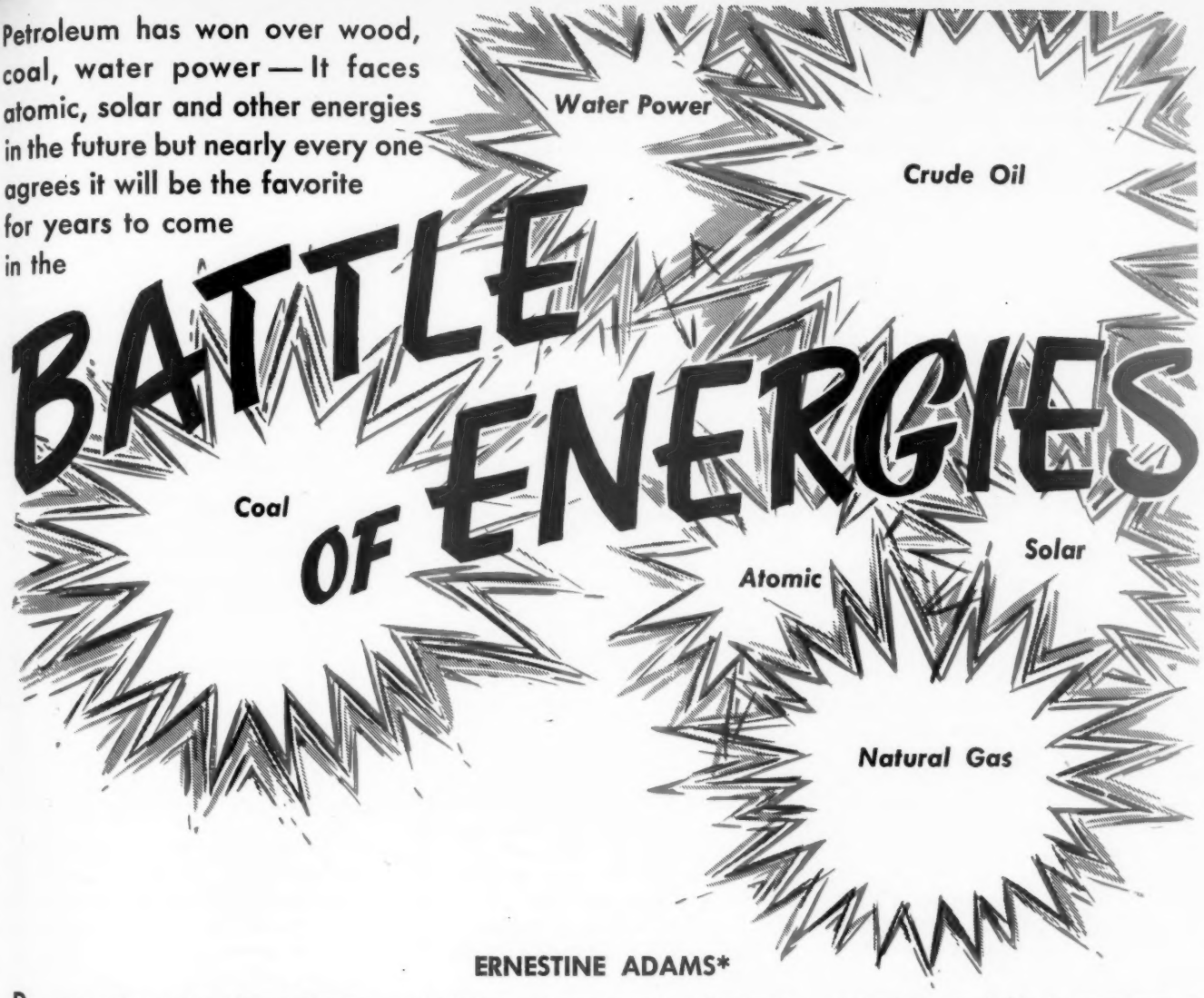
Another article describes an automatically controlled booster station. By today's standards of automatic stations this installation was extremely simple, but at that time it was an important progressive step.

Refining equipment and processes today and those of 25 years ago are hardly recognizable as being kindred operations, except that their basic purpose was the same — producing motor fuels and lubricating oils. Elimination of gums from gasoline without destroying anti-knock properties, and the manufacture of motor fuels of high volatility and high anti-knock ratings were important topics. Refiners were being told more about the use of instruments in their plants, which were by no means as prevalent as they are now.

Industry engineering-operating problems are widely discussed today, but it must be remembered that a comparable interchange of views and information did not exist prior to 25 years ago. The first issue of The Petroleum Engineer in October, 1929, might be said to have marked the beginning in this respect.

Petroleum has won over wood, coal, water power — It faces atomic, solar and other energies in the future but nearly every one agrees it will be the favorite for years to come in the

BATTLE OF ENERGIES



ERNESTINE ADAMS*

PETROLEUM is the biggest chapter in the history of energies used by man. Wood, farm wastes, water power, and muscle brought man through thousands of years of painful progress. Coal quickened the advancing step in the economic march. Less than a hundred years ago petroleum set a new pace—running, then racing ahead to greater and greater power until today no one can imagine life in the United States without petroleum, and the rest of the world would like to make use of more of the magic energy to catch up with the United States in economic well being.

At the present time there is no energy on the horizon that is likely to depress the expanding curve of petroleum use for at least a score of years and probably many beyond that. As new energies are developed, expansion of demand should readily offset added supply.

To get some idea of petroleum's place in tomorrow's energies we asked a number of industry men who have to think about those things anyway to help us look into the future to see how oil and natural gas fitted in the picture.

These men sound like the voice of the industry always sounds—the strong confident notes of a triumphant march with a recurrent but minor blues melody called "we got troubles."

As Harold Decker, Houston Oil Company, gives the theme: "There has never been a time in the history of the petroleum business when we have had as many headaches confronting us as we do at this time, but never have I had greater faith in the future."

The petroleum industry's troubles are always small beside its triumphs but some of the difficulties, as the Houston Oil Company president indicates, loom large and dark.

Regulations of Gas Producers

The latest refrain of the *Troubles Blues* results from the Supreme Court decision that natural gas producers come under Federal Power Commission regulation and the subsequent freezing of prices by the FPC. Opinion of petroleum industry leaders is that the decision is unfair and that in the long run both industry and the consuming public will suffer.

States James E. Allison, president, Warren Petroleum Corporation:

"Long term effect of Federal Power Commission regulation of gas producers will be to limit the supply of natural gas available to consumers to a much lower figure than it would otherwise have been. I have talked to many people in the oil and gas industry since the recent decision of the Supreme Court and find that most of them are not even thinking of developing additional gas supplies. They are worrying about what they are going to do with the supplies they have already developed, and are not going to get themselves into more trouble by additional exploration and development."

L. S. Wescoat, The Pure Oil Company, is disturbed about risks without adequate return. He says:

"Effect of FPC regulations of gas producers is of tremendous importance to the public and to the petroleum industry. Unless this situation is changed in the near future through legislation, it will have the effect of substantially lessening the availability of natural gas to the long line transporters. Obviously, in a risk business such as the petroleum industry, the financial returns allowed under utility regulation are totally inadequate, and the drilling for gas as such would in my judgment be insufficient to maintain the reserves necessary to supply the existing long line requirements."

A different view is expressed by

*Managing Editor.

R. L. Tollett, president, Cosden Petroleum Corporation, but he sees the situation from the standpoint of present owners of producing properties. In his opinion:

"The FPC regulation for gas producers will have no long-term ill effects. It may cause some trading and require some of the producers to sell properties to investors. This could be as often good as bad. An analogous situation obtains with respect to the statutory depletion allowance. Should the owner of oil in place be denied a statutory depletion allowance, he would sell his interest and take capital gain. His successor in title would then take depletion on cost. In most cases, tax revenues would be impaired."

As S. B. Irelan, president, Cities Service Oil Company, points out, it is difficult to judge results of FPC regulations of gas producers until a price-fixing policy has been established. He mentions that:

"The Commission has already frozen gas prices as of June 7, 1954. Escalator clauses, renegotiation provisions and favored nation clauses of contracts, under which gas is currently being sold, are no longer effective unless approved by FPC. Such action indicates the Commission intends to supervise closely the price paid to the producer.

"Natural gas development has expanded rapidly during recent years under competitive conditions in a free market, but under Government control with a price-fixing ceiling, the incentive for future development is sure to be greatly reduced. Producers may look to intrastate markets for an outlet or may consider selling out to the gas pipeline companies doing an interstate business. Many of these companies have subsidiary producing companies. The slowing down of gas development will naturally curtail expansion of new markets.

"All of the above suppositions could be out of the picture if a future congress will clarify the present law such that its original intent will be clear and definite."

Slackening of Increase

The petroleum industry was set for another increase in demand for 1954 similar to 1953, instead of which the rise slowed. This is another blue note which fits into the present and near future but fades from the picture of a few years hence.

Some of the causes of the slackening are mentioned by C. T. Foster, president, Standard Oil Company (Ohio), who says: "Although the demand for petroleum products during the first half of the year has been slightly higher than a year ago while industrial production has fallen con-

Natural Gas—*A Look Ahead*

W. G. SKELLY

President, Skelly Oil Company

THE Supreme Court's decision in the Phillips Case (overruling an earlier decision of FPC) was erroneous, I believe, because it seems plain that Congress intended by the Natural Gas Act of 1938 to exclude natural gas producers as such from federal control. Of course my thought about this is water-over-the-dam unless and until the Court grants a rehearing and changes its mind.

But the question now is, where do we go from here? While I write this, many protests are going forward to FPC from gas producers, large and small, pointing out the unworkability of Order 174-A and pleading for a postponement of its enforcement until the Supreme Court acts upon the pending application for rehearing and until the Commission can give notice to oil and gas men and hear and weigh carefully their views on points vital to the succesful operation of the oil and gas producing business.

That an adequate supply of these basic commodities is indispensable to our national security and prosperity is true beyond need for argument. The federal strait jacket embodied in Order 174-A would lay an axe at the root of this tree and adequacy of gas and oil would begin to wither. Why? Because a decent profit incentive and individual freedom of action which together form the mainspring of oil and gas production, would no longer exist. The sponsors of FPC regulation have as their declared objective cheap gas for consumers at the northern and eastern ends of the great transmission lines from the gas producing regions of the southwest. But it is a stupid economic blunder to think such a result can be achieved by the federal regulations they advocate and, temporarily at least, have achieved.

Surely it must soon become plain to even these proponents that the way they have chosen to depress the price of gas transported and distributed to consumers will inevitably recoil upon itself and defeat its own purpose of diminishing the supply of gas at points of production, thus eventually causing consumers to pay more money for diminishing available volumes.

I am optimistic enough to think that such an unhappy result will not come about, for these reasons:

1. If the Supreme Court's decision in the Phillips Case is wrong, as I believe, that august body may recognize its error and grant a rehearing and a different decision;

2. Present members of FPC average high in ability and character, and prior to the Supreme Court's decision believed and acted on the belief that gas producers as such were excluded by the statute from their jurisdiction;

3. Congress has power to amend the statute to say again, even more emphatically, that federal regulation of the gas producing business is not intended.

The logic in support of such Congressional action (if it becomes necessary in order to extricate gas production from the present paralyzing complex of financial and operating problems resulting from the Supreme Court's decision and FPC Order 174-A) is unanswerable, whether looked at from the standpoint of gas producers or of gas consumers.

It is my belief that national interest will soon cause the indispensable gas-producing end of the petroleum industry to emerge from the present confusion, which is not caused by any act or omission of its own. A fundamental and incontrovertible truth, well known to engineers and economists, is that natural gas at places of production has always been and is now priced more cheaply, based on Btu value (to say nothing of cleanliness and convenience) than any other fuel. That this higher value in relation to price is a reality even at distant points of consumption is evidenced by the spectacular growth of gas consumption in recent years, exceeding by far the growth in demand for any other fuel.

siderably below the peak 1953 levels, declines in employment, income, and new car registrations—all reflecting the drop in industrial activity—have been major factors in the slackening rate of demand for the petroleum industry. Other factors affecting the total demand picture are reduced military requirements, a warmer than normal heating season, and a decline in exports resulting from increased foreign refining capacity."

T. M. Martin, president, Lion Oil Company, feels there are three main reasons for the smaller increase in 1954 for petroleum products:

1. *Increased use of natural gas;*
2. *Tremendous increase in the use of television and air conditioning;*
3. *Inadequate national highway system.*

"In connection with number three, which I believe will have the greatest long-range effect," he added, "it is important that the petroleum industry, the automotive industry, and accessory industries join hands in working with all departments of government to do something right away about Mr. Eisenhower's $50-billion highway building program."

Families in the South, whose homes are being air-conditioned at a rapid rate can attest to the second cause. Where the whole family formerly piled into the car in the evening "to cool off," the members are now reluctant to leave cooled homes and ready entertainment.

Jake L. Hamon concurs on the highway obstacle: "The highway system needs to catch up the lag they lost in World War II," he says.

The coal industry is making some inroads by cutting prices and doing a better job of selling, R. L. Tollett says. He also believes gasoline efficiency has something to do with less increase.

"The demand for gasoline is greater this year than last, but not much greater. In my opinion and without any statistical support, I feel that improved quality of both premium and regular grades has increased the mileage obtained per gallon. People are probably driving as much or more. We know there are more automobiles and trucks. Gasoline advertisements are not false claims. We actually have better gasoline than we had last year. The compression ratio of automobile engines is somewhat higher on the average. I sincerely believe that improvement in automotive gasolines has given the consumers more for their money."

Dr. Charles F. Kettering, famed automotive engineer, repeats this opinion for the 25-year period. He says: "Our cars are now lasting two and a half times as long as they used to, and they are only using 60 per cent as much fuel . . ."

M. J. Rathbone, president, Standard Oil Company (N. J.), mentions another reason: "The growth of railroad diesel oil has slowed down perceptibly from past rates, reflecting the approaching completion of dieselization programs for many of the railroads." He adds, however: "We look for improvement in oil demands over the balance of the year, based on the

Highways—*Star in Petroleum's Future*

GLENN E. NIELSON

President, Husky Oil Company

PAST history has shown that American industry repeatedly has set its sights low in trying to project or appraise its future growth and the possible future demand for its products and services. I think we in the petroleum industry have at times fallen into this way of thinking. I do not believe that 20 years ago, for example, the industry envisioned the tremendous market that would develop for petroleum products on the farms of the nation, or if it did envision that growth, I am sure it did not expect it to come so rapidly and be the complete swing to mechanization that it has.

If the nation carries out the road-building program now needed and now under serious consideration in state and Federal quarters, the sale of petroleum light-end products will be increased materially.

We know that good highways have in large measure contributed to the expanding automobile ownership and the expanding gasoline sale of the last 25 years.

Tribute, of course, must be paid to the automobile industry for its great engineering advancements, but in 1925, had that industry been able to market the quality cars it is marketing today, it would have sold no more units than it did of its then current models of 1925. The nation simply did not have the highway system needed to permit widespread ownership and use of automobiles.

We would be foolish, indeed, if we felt that truck and automobile ownership and use was now close to saturation. New families are moving into first-car ownership each year. The trend is toward two-car ownership. This alone gives pressing need for attention to the problem of highway expansion.

Further, expansion and improvement of our primary system of highways into faster, safer, more pleasant-to-travel thoroughfares is going to increase greatly automobile and truck ownership and use in the great congested centers of population. Similarly, as the secondary roads and farm-to-market roads are hard surfaced, the farmer will be brought closer to the town, and the town to the city both in distance and travel time. This will mean more frequent travel over these roads with a resultant increase in the sale of petroleum products.

One point, however, that I think deserves greater stress in the industry than it is now receiving is the position that another industry product, asphalt, can play in helping to develop this increased market for gasoline and motor oils.

Last November the Board of Directors of the API appointed a special committee to study the question of asphalt and America's highways. The findings of this committee show asphalt to be the only indispensible ingredient of our highway system. In other words, were it not for asphalt, we could not as a nation afford such a complete highway system as we now have. Asphalt is the proven equal of concrete for carrying any loads or traffic. Maintenance of asphalt pavement is easier and cheaper than any other. Asphalt has proved that it gives more miles of better roads for less dollars.

It behooves the petroleum industry, therefore, to go all-out in promoting the use of asphalt in the great highway construction program now before the nation. In this effort it will be working for more miles of top-quality highways for every budget appropriation made for highway purposes. It will be, in this way, helping to build the expanded gasoline market of tomorrow. And this effort will not be productive of profit to the petroleum industry alone. It will also help the American taxpayers generally, whose tax dollars must pay for the greatly expanded and improved highway system now needed in the U. S.

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expected upturn in general business and normally cold winter weather. New home building as well as the output of passenger cars and oil burners have been holding up well in recent months and these can be expected to show their effects on oil consumption over the coming period. For the year 1954 as a whole, we expect U. S. oil consumption to be at least 2 per cent higher than last year.

S. B. Irelan lists eight reasons for slackening of demand increase:

1. *Excessive stocks of refined products, especially gasoline.*
2. *Imports, both crude and products.*
3. *Desire to travel on the part of the public has been reduced by congested highways.*
4. *The public is a little spending conscious due to the current slight depression.*
5. *Reduced demand for heating oils due to abnormally warm weather so far this year.*
6. *Gas is replacing heating and residual oils to a limited extent.*
7. *Decreased demand for residual oils due to industrial recession.*
8. *Decreased demand for military purposes.*

Ole Berg, Jr., whose British-American Company markets in Canada, pointed up the fact that increase in consumption has been holding up outside the United States.

"There is no appreciable slackening in Canada. The country's estimated gasoline consumption for 1954 will be 74 million barrels, a substantial increase over last year's figure. In the overall picture of petroleum consumed, the estimated figure for 1954 will be 8½ or 9 per cent more than the previous peak year of 1953."

Future Problems

Although the two top problem spots today are held by over-supply and the FPC regulation of natural gas producers, the long range problem faced by the petroleum industry is the strong competition of new energy sources of incredible potentiality.

The two energies mentioned most frequently as new power sources which might compete with petroleum are atomic and solar. There are those who freely predict that these two energies will power the future, but when we get down to details the future has been pushed far off.

Atomic Energy

In the coming battle of energies, atomic energy has several counts against it, among these being that it is expensive, difficult to use, and inconvenient to handle. Ole Berg, Jr., makes these observations: "I cannot see atomic energy having an adverse effect on petroleum demand in the near future, and certainly not to the extent some would have us believe. While atomic power will be a welcome additional source of energy to meet the growing requirements of industry in the years ahead, the bulk of petroleum products will continue to go, as today, in ever-increasing amounts to automobiles, industry, domestic needs, and petrochemicals.

"It is possible that atomic energy could power trucks and automobiles, but hardly feasible. Aside from the problem of obtaining enough material for reactors and the cost of units powered by such reactors, automotive engineers would be faced with staggering design problems. An atomic reactor would need a shield a foot thick. How could attendants do casual work under the hood of such a car?"

THE PAST is only a matter of curiosity unless it is used to educate the present and plan the future. On this 25th anniversary of *The Petroleum Engineer* we present here a glimpse of what some of the men of the petroleum industry think about the place of oil and natural gas in the world of tomorrow.

In the opinion of M. J. Rathbone, atomic energy will become competitive with other energy sources in a limited field within the foreseeable future but a large part of the oil market should not be affected.

He points out that: "It would appear that the generation of electric power and ship propulsion are the two most likely fields for atomic energy development, and neither of these is a major proportion of today's oil market. Further, the oil product upon which such competition would fall is low-valued heavy fuel oil, a material which the oil industry is continually striving to convert to higher valued products. Last year less than three per cent of the oil consumed in the United States was used in the generation of electric power by utility companies, and only a part of this is subject to atomic energy competition. The oil consumed worldwide for propulsion of both civilian and military ships represents roughly 10 per cent of total world petroleum demand and is a more significant market. However, for many years the use of atomic energy in this field will probably be limited to large naval vessels. Thus it appears that the oil industry need have no apprehension over the commercial development of atomic energy."

There is a prevailing confident belief that atomic energy will fulfill a new demand, not supplant petroleum energy. T. S. Petersen, president, Standard Oil Company of California, says it this way:

"The development of atomic energy for commercial use is not expected to affect the demands for petroleum since most responsible authorities believe that it will be impossible for petroleum, or other fossil fuels, to supply completely the tremendous energy demands of the long-term future. Atomic energy is expected to act in a supplementary capacity.

"There would have to be some change in the balance between products, but it is believed that any change required would be made gradually in the normal course of refinery expansion and modernization."

William T. Payne, Big Chief Drilling Company president, has no fear of competition but looks forward to the progress which atomic energy can fuel. He says:

"Having witnessed 35 years of progress in the engineering and technical phases of finding, producing, and refining oil, I am naturally an enthusiastic believer in the future of scientific development of atomic energy. It is my prediction that by 1975 from 4 to 12 per cent of the country's electrical power will be furnished by nuclear power plants. I do not mean by this that atomic power will supplant oil and gas in the energy field during this century. High investment costs and problems of shielding against dangerous radiation indicate that atomic energy is not suited to the operation of automobiles, trucks, airplanes and railroad engines."

Solar Energy

Although atomic energy is the one most talked about these days, the use of sun energy to meet future demand is another strong possibility. Palmer Putman in "Energy in the Future"* quotes J. B. Conant, former president of Harvard and now high commissioner of West Germany, as saying in 1951 that we will become wholly dependent on solar energy in A.D. 2050. This seems improbable from our spot in the present but as William T. Payne points out, "Solar energy could become

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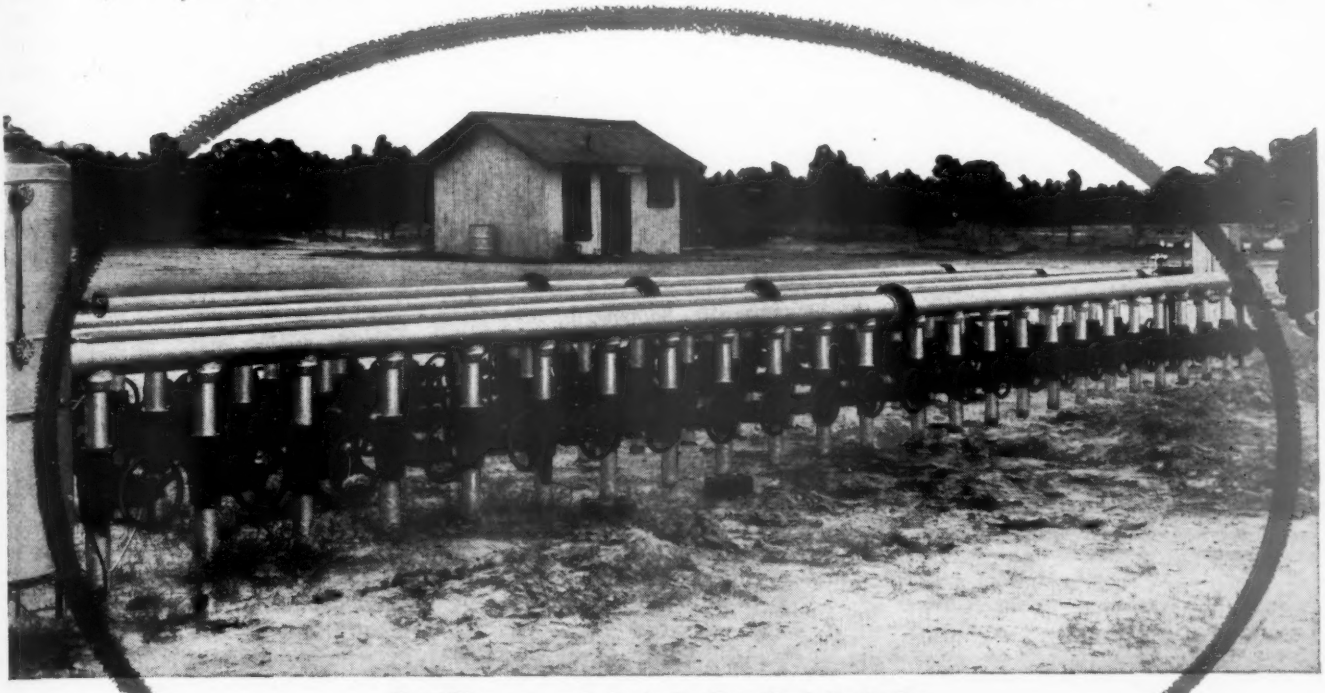

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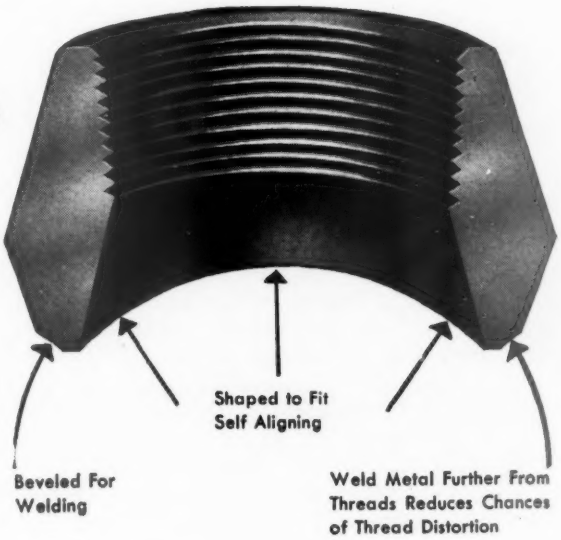

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The Unfolding Challenge

WALTER S. HALLANAN

President, Plymouth Oil Company

WHEN we consider that mankind has made more progress in the 95 years since the birth of the petroleum industry than in all of the 6000 years of previously recorded history, none but the most daring would risk a prediction as to what the future holds.

Everyone certainly is conscious that we stand upon the threshold of greater and more electrifying discoveries than those which have so radically changed the world in the last century. The development of atomic power and the destruction of the sound barrier are but two of the many omens of a vastly changed society.

As we have moved forward the speed of our advance has quickened in cumulative fashion. The pace grows swifter every day. We are made aware of this as we note that new elements and new machines which revolutionized our economy today are practically obsolete tomorrow. The laboratory constantly remains ahead of the economy.

This scientific and technological revolution is destined to continue at ever-increasing speed. The oil industry most certainly will be effected by the inevitable changes that lie ahead. Whether these changes will be for better or worse no one can say. It is generally recognized that in the years ahead atomic power will displace some of the energy now provided by petroleum. On the other hand, it must not be overlooked that this same atomic power may open the door to new uses for oil which no one can now envision. In any event, the petroleum industry cannot hope to meet the unknown challenge of tomorrow unless it first solves the unknown problems of today.

Problems are nothing new to the oil industry. Its unique strength and freedom stem from the fact that it has virtually raised itself by its boot straps over one seemingly unsurmountable obstacle after another. Despite that 95-year record of overcoming the most awesome difficulties, we must realize that the problems of this hour—problems growing out of the world over-production and slackening of the increase in demand—are more numerous and more serious than any since the depression days of 20 years ago.

If we courageously face up to these present-day ills and find the remedy for them, we will be better prepared then to meet the unfolding challenge of tomorrow.

a factor in the future. A surprisingly efficient solar battery was recently announced by the Bell Telephone Laboratories. However," he goes on, "I do not expect either atomic energy or solar energy to become major competitors with oil or gas in our time."

In view of the long history of experimenting with solar energy, there does not seem to be a major reason for believing advancement in this direction will come soon. About 1670 the concentration of solar energy by means of lenses was practiced by the French physicist, Berniere.

Solar energy has been trapped and stored successfully for space heating in the U.S. but so far is considered uneconomic.

In discussing whether solar energy would find a place in chemical processing, an idea now limited to research, Augustus C. Long, president, The Texas Company, stated:

"It is not believed that any appreciable amount of solar energy will be used in chemical processing because of the relatively low temperatures attained. It is regarded as quite probable, however, that there will be an increase in the use of solar heating of homes and other buildings. The temperatures required for such heating are considerably lower than those required for most chemical processes. Heat pumps can be used to obtain somewhat higher temperatures with solar heating but the installation costs are not favorable to adoption of such a scheme under present conditions. Solar heating might find some limited applications in the low temperature evaporation of liquids from solutions particularly where time is not a factor. It is true that certain chemical processes can be accelerated by exposing the reacting materials to light. The energy involved is quite small, however, and for reasons of control it is generally preferable to use special electric lamps for this purpose."

Energy Used in Industry

This leads into another field of energy competition—in the industry itself. Here the problem is to find the cheapest and most efficient energy to produce, manufacture, and distribute oil and gas. The industry uses vast amounts of its own products and of electricity and other energies. New methods and new energies are being tried out to increase oil and gas supply and to keep down the cost of providing new supplies.

Atomic energy has been useful in the research laboratories and is successful in making pipe line transmission more efficient. The idea of using sun energy in processing is in the incubator stage. Experiments in progress on the Pacific Coast indicate sonic energy can be used in drilling operations and in operating subsurface pumps. Thermal energy is being tried out for more efficient production in old oil fields.

J. L. Latimer, president of a company taking a lead in use of thermal energy in production, the Magnolia Petroleum Company, has an open mind about these research projects. He says:

"Use of sonic or vibrational energy to drill wells has been the subject of considerable amount of research in recent years. We do not know as yet whether these new methods will be economically attractive, but experimental results look encouraging enough to warrent continuation of the work. This also applies to thermal energy as a means of producing oil from older wells. We do not yet know the economics of the process, and only additional field tests will tell us if subsurface combustion is commercially practical. Whether by this means or other methods, the industry is certain to find still better ways of recovering higher percentages of oil from our oil reservoirs."

The majority of informed men in the industry seem to agree that these energies have a place in petroleum's future. At the present time most of these methods are uneconomic but further effort will certainly be made to bring costs within reason and by selective use, this development of varied energies should increase the efficiency of operations.

As Richard T. Lyons, president of Union Sulphur and Oil Corporation, says, predictions are quite often a reflection of hopes; "it is my hope that oil wells may be drilled more cheaply, and if sonic energy can do the job any cheaper than present methods I would be very greatly interested."

Changes in Requirements

The petroleum industry, besides being affected by new applications of energies is also greatly influenced by

changes in demand. Upgrading of products in the years since the war has probably done more to increase the value of petroleum output than expanded demand. There was the swift rise of liquid petroleum gas products and the rising demand for petroleum products and by-products in the petrochemical field.

It seemed at one time that the requirement for aviation gas was insatiable. Then jet turbines began to appear in military aircraft and now their use is growing rapidly.

Experiments are being made of the use of the jet turbine for ships and automobiles. Costs are still high but possibilities of development are immense. Chrysler advertises advancement of the gas turbine engine for automobiles.

Henderson Supplee, Jr., president of Atlantic Refining Company, thinks widespread use of jet turbines would have an influence on refinery programs "although probably not more than the changing percentage yields of products during the last 25 years have influenced past refinery programs."

Future application of gas turbines to ground vehicles should be watched closely by those concerned with processing, according to Texas Company's President Long: "Although a number of automobile companies have initiated work on gas turbines for automobiles, there is no indication as yet that they will come into widespread use for this purpose for some time. Activity in this field must be carefully followed so that any positive trends can be taken into account in any long-range planning on refinery equipment."

President Rathbone of Jersey Standard puts requirements into the statistical picture: "Since World War II the use of aviation jet turbines has been growing very rapidly, primarily for military aircraft. This expansion will probably continue for many years to come, although the growth rates in the future will become less spectacular. A recent government release estimated that half of all U.S. military planes might be jet turbine-powered by 1957.

"Civilian use of jet aircraft in the United States is still in its infancy. There are no commercial jet turbines in operation today, and it will be quite a few years before enough units can be produced to represent a significant share of the total fleet. However, even if all commercial planes were converted to jet turbine operation their fuel requirements should not present a serious refining problem, unless especially restrictive properties of the fuels were specified. Total consumption of fuel by commercial airplanes is currently less than one per cent of total petroleum consumption. Even allow-

The Right to Solve Problems

ROBERT G. DUNLOP

President, Sun Oil Company

IN 1929, the year which gave birth to *The Petroleum Engineer,* many serious, perplexing problems confronted the oil men of America — just as they have in virtually every year since.

But 1929 marked, not only for the oil industry but for all Americans, the closing of an era and the beginning of an interim period between that and another.

Some oil men in that year were worried about the possibility of oil shortages; others about the possibility of over-supply. All refiners were concerned about the need for improving gasoline quality. Many anticipated solutions would be found in the new technological advances that were beginning to be made with rapidity. Others were fearful that, lacking understanding of the new progress, they would be left behind. A few sensed in the dark clouds that spread from Wall Street the coming of a storm that would shake the foundations of American life.

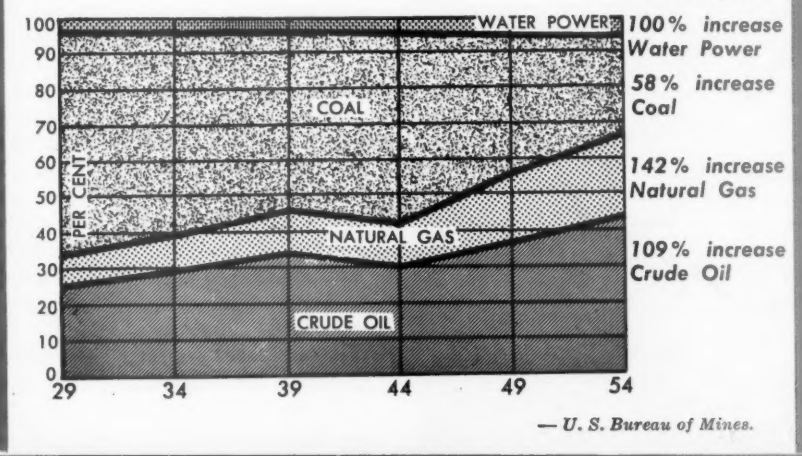
Looking back over that 25 years, the problems of 1929, fearsome though they were at the time, do not now appear to have been as momentous as today's problems. This is so because in the years that followed they were met and were solved. The unknown then ceased to exist and with knowledge came confidence.

Those problems were solved, primarily, because American oil men held fast to the faith and traditions of their country. They rejected the virus of Statism in the thirties. They remained loyal to the American precepts of individual initiative and self-reliance. They refused to surrender their freedom of action for will-o'-the wisp security. Thus were generated their energy and resourcefulness to solve, in honor and with progress, the problems of those years.

In that quarter of a century *The Petroleum Engineer* rendered great service by reporting all these things, disseminating knowledge of the widening technological arts and skills of the industry and spurring the men of oil to remain true to the sources of their industry's greatness —an insistence on individual freedom and opportunity.

So long as oil men continue their fight to preserve individual freedom and opportunity in this Nation, no problem of today or tomorrow can remain insoluble.

MAJOR U. S. ENERGY SOURCES



— *U. S. Bureau of Mines.*

Percentage increases of atomic energy, which will have made considerable headway by 1975, especially in supplying electric power, and solar energy, are not estimated because present use is so limited.

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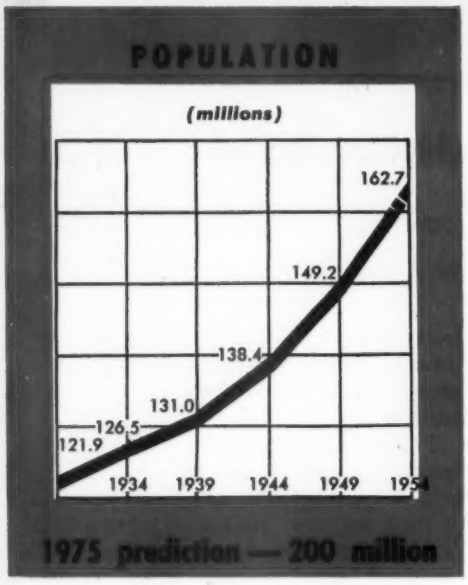
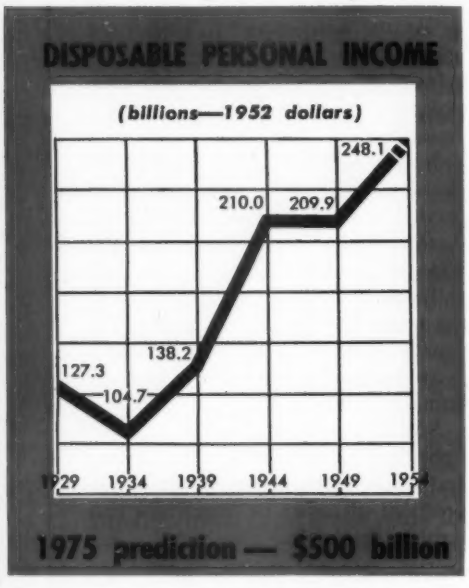
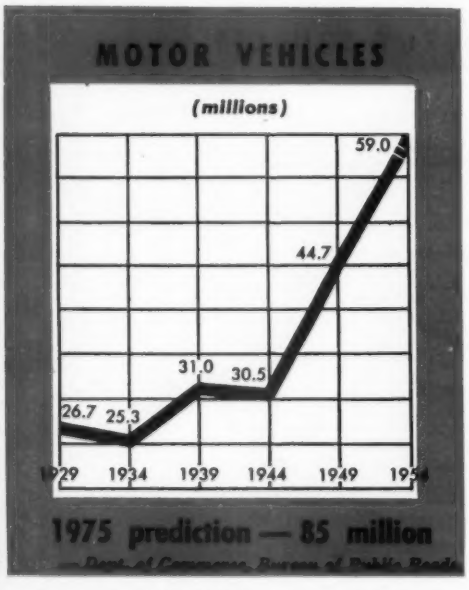


Our prime resource is people. Estimate is balance between Paley Report and Census Bureau.



Spendable income almost doubled since 1929. Taxation jumped sharply in the period 1944-49.



Figures do not include tractors. There are some 4,200,000 tractors in the U. S., currently.

ing for the considerable expansion to be expected by the airlines and the higher consumption of jet aircraft, it will surely be many years before civilian jet fuel requirements amount to more than a few per cent of all petroleum consumption.

"Based on its current specifications, jet fuel is a relatively easy product to manufacture in refineries. Under peacetime conditions the petroleum industry should be able to meet anticipated requirements for both military and civilian jet fuel for years with changes in operational planning and only minor changes in refining and handling facilities. In the event of war, of course, the situation would be different. Nevertheless, a large volume of gasoline and middle distillate could probably be diverted rapidly to jet fuel production in less time and at lower cost than would be the case of aviation gasoline."

The jet engine is one of many developments which the petroleum industry must watch and plan for in advance.

Supply of the Future

The forecasters have almost stopped predicting that the United States will be out of oil in 15 or 20 years. The last statement by the U. S. Geological Survey indicated supply of petroleum would be up to the petroleum industry. The period will doubtless come when hydrocarbons will be insufficient and the people of the world will be forced to turn to the sun for energy but the 100 years estimate of Dr. Conant seems too short a time for that to happen.

In their paper on "Meeting Future Petroleum Demands" given in 1952 before the API, John E. Swearingen and John W. Boatwright estimated productive capacity of liquid hydrocarbons as approximately the same as demand in 1967, but with actual production running 1,500,000 under demand, the remainder being imports. Most comments on present imports fail to take into account the fact that today productive capacity in the United States is adequate to supply domestic needs without imports.

Swearingen and Boatwright estimated a proportionately larger margin of capacity over production.

On the other hand Eugene Ayres and Charles A. Scarlott in "Energy Sources—The Wealth of the World"† indicate that the peak of production in the United States would be sometime "between 1955 and 1967, or, more plausibly, between 1955 and 1960. The earliest date estimated by specialists in 1950 is 1955. The latest date is 1960."

These authors also state: "We cannot believe that this fossil-fuel era in which we live, an era which may soon start its climatic approach to exhaustion, will be regarded by historians of the future as a period in which energy has been uniquely abundant. Instead, there is every reason to expect that succeeding eras will provide still greater abundance of energy from our constant sources."

For so many years the petroleum industry has heard the cry of "we're running out of oil" only to come up with temporary over-supply that the refrain now falls on deaf ears. For the next decade or so, new potential land areas and the continental shelf should hold the curve on its upward trend. The important factor is economics—to keep prices high enough to offer a strong incentive and costs low enough to meet competing energy sources.

Demand of the Future

Future demand can be measured only by the past and man's imagination. Often the measure is too small for what it finally holds.

Speaking of our vigorous past Frederick C. Mills in "Productivity and Economic Progress"* says:

"Over the last half century the real national product of the United States increased five-fold, while population doubled. Output per capita of the population increased two and one-half times. Here was the basis of a substantial advance in economic power and in levels of consumption. Over this same period the total volume of human effort going into production (measured by manhours of labor input) increased by 80 per cent. The great gain in total output was won with an increase in labor input well below the increase in population. Here is evidence of a gain in welfare in another dimension—a saving of effort and a lightening of the toil by which the material needs of life are satisfied.

"The major instrument used in the winning of these dual gains was enhanced productivity. During this period there was an unbroken advance in average physical output per manhour of work done. Decade by decade the effectiveness of productive effort increased. In the final decade output per manhour of labor input was 2.81 times what it was 50 years before."

This "effectiveness of productive effort" he speaks of has been gained by our ability to find energy sources and to use them efficiently. Output of energy per capita in the United States is far higher than in any other country in the world. Our energy sources have been the cheapest of any country because of almost free competition.

Future demand for energy is bound to soar. One of the most extensive economic studies ever made by govern-

†McGraw-Hill Book Company, Inc., 1952.

*National Bureau of Economic Research, Inc., Occasional Paper No. 38.

ment and private industry—the Paley Report made in 1952—estimated that in 1975:

U. S. population would have 42 million more people

Spending, at present prices, would be double

Industry would be making 40 per cent more consumer hard goods and 50 per cent more capital equipment

Jobs would exceed 79 million and pay would be higher

Homes would be increasing by 1½ million a year

Oil and gasoline demand would be double—or about 15 million bbl a day

Natural gas markets would require more than 24 trillion cu ft a year

Electric power needs would be about 1.4 trillion kilowatt-hours a year.

Coal requirements would be nearly 800 million tons annually

The population growth with its rising standards (and the Paley Report uses a comparatively modest rise) calls for the tremendous volumes of energy sources listed. Atomic and other energies will be useful to fill supplementary needs, especially in fueling electrical power. At present water power supplies only a third of the electrical power needed and thermal generation supplies the remainder. This requires low grade fuel and the petroleum industry has progressively less low grade fuel to fill the demand.

Some economists believe that efficiency in use of energy sources has reached some kind of limitation and that future increase in output must be met by greater energy input. In this event larger quantity increases of energy sources must be made. In "Energy Sources," the authors find that per capita consumption has increased almost two and one-half times in the same period "that the actual utilizable energy per person has increased four or five times."

It seems unlikely that we have reached a leveling of intelligence and ingenuity; it seems more probable that cumulative knowledge would be a basis for more rapid progress in efficiency unless hampered by political philosophies. If this view is accurate, energy input probably will not reach the demand estimated by the Paley report and others even though output does.

These requirements for the future will not suddenly appear in 1975. They are beginning now.

Arthur F. Burns, chairman of President Eisenhower's Counsel of Economic Advisers, and, importantly, a conservative economist, said recently: "Our country has the capacity to raise physical production from its current annual level of about $360 billion to $440 billion or even more in a mere 5 years. It is essential for our national security, as well as the interests of increasing welfare, to realize this potential growth."

The petroleum industry, from all indications, is on the threshold of its greatest growth and service. Consumption in the coming years could easily pass the most optimistic predictions for potential requirements are immense. From all signs we are approaching a Black Golden Age.

In his "Energies of the Future," Palmer Putnam, consultant to the U. S. Atomic Energy Commission, states: "If present preferences continue it is not difficult to imagine that liquid fuels will be contributing between 65 and 85 per cent of the total within 25 years."

Men of the petroleum industry look from the present into the future with a confidence based on past performance. They plan now for 5, 10, 15 years in the future. They must find oil and gas this year to run through a refinery not yet built. They must learn now the best process for a product not yet needed. They must build soon long transmission lines to serve customers not yet sold.

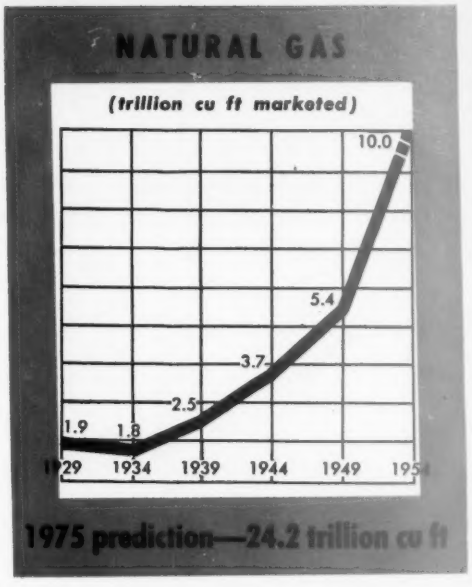
They can do it on one condition—freedom from too rigid controls, especially price controls such as those imposed upon natural gas producers by the FPC. Conservation regulations are needed and accepted but these do not have the atrophying effect that price setting has.

It Can Be Done

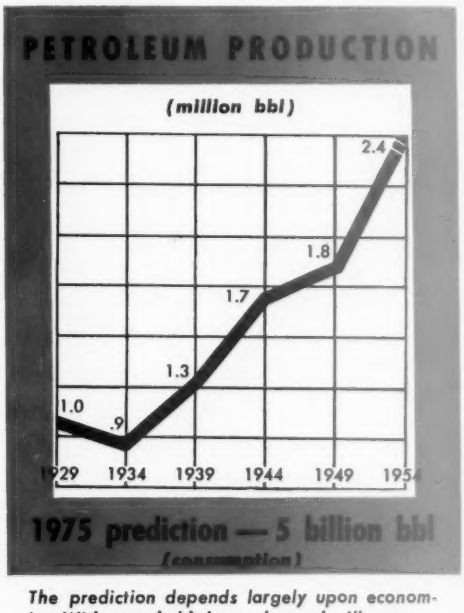
The needs of our country for power sources must be filled efficiently if we are to maintain the required volume. There is no room for waste in the future. This can be done only if there is free competition among all energies. Atomic energy is already heavily subsidized and only recently have private companies been allowed to build and own atomic reactors under government license. There is presently widespread rumor that some method must be found to subsidize the politically important coal industry. Taxpayers have long been paying for hydro-electric power to benefit limited areas.

Only competition on the service level can produce the energy volume and efficiency demanded by the future. Only the twin forces of supply and demand can shake out the sands of obstruction and confusion and leave the priceless gift of abundant energy. In the battle of energies, every one loses if the best power does not win.

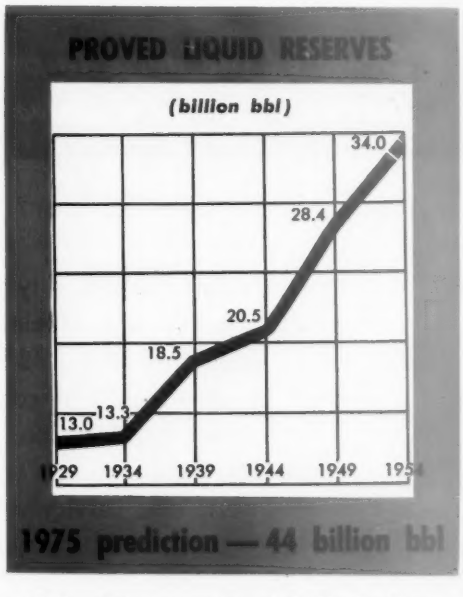
Only in economic freedom can we select efficient uses for our new and old energy sources of power; then the eager future can use them all and use them well. * * *



Of all climbing curves, natural gas is most impressive. It expanded 5 times in 25 years.



The prediction depends largely upon economics. With costs held down, demand will soar.



While politico-economists cried "Shortage" petroleum reserves grew 2½ times in 25 years.

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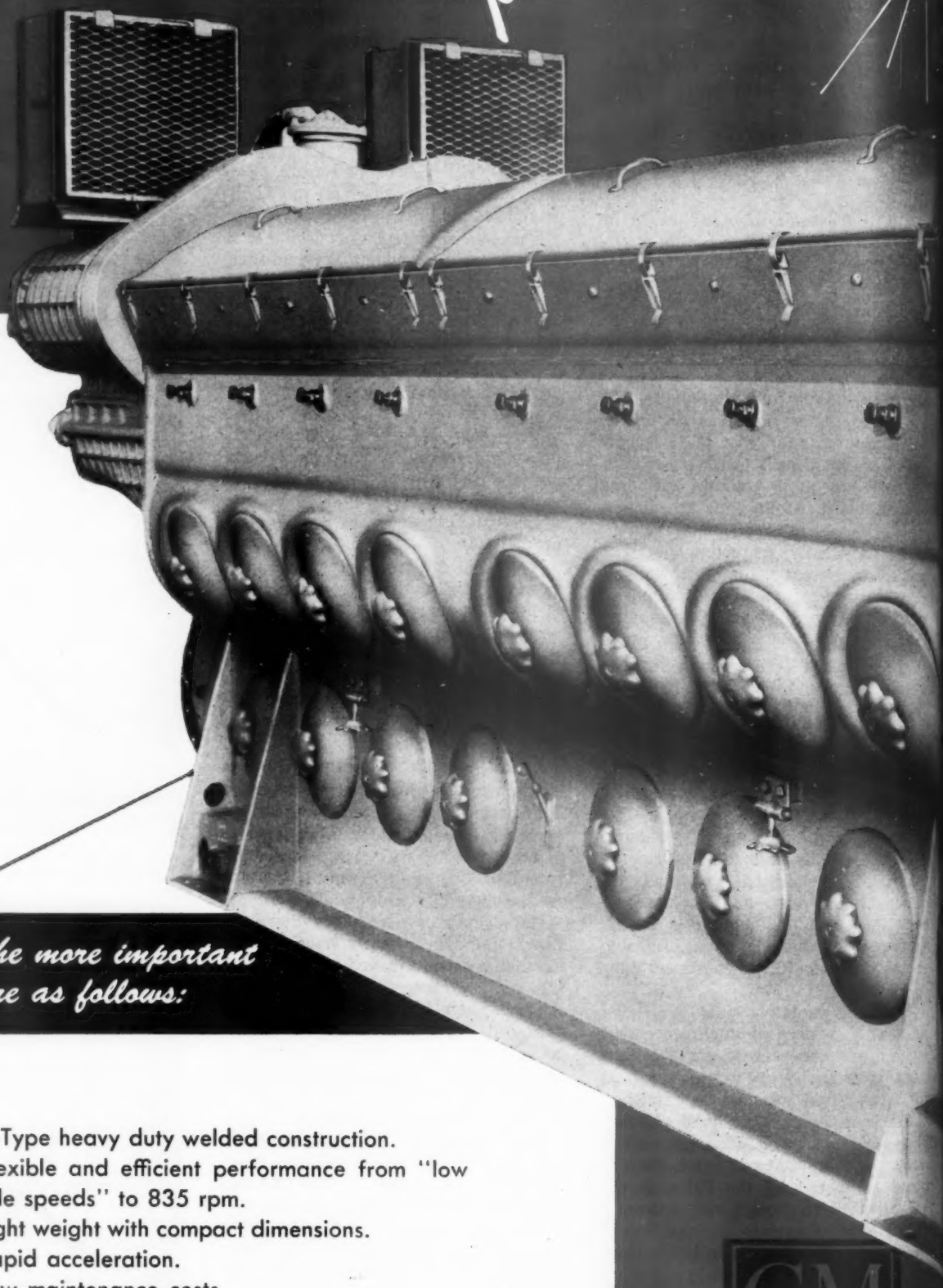

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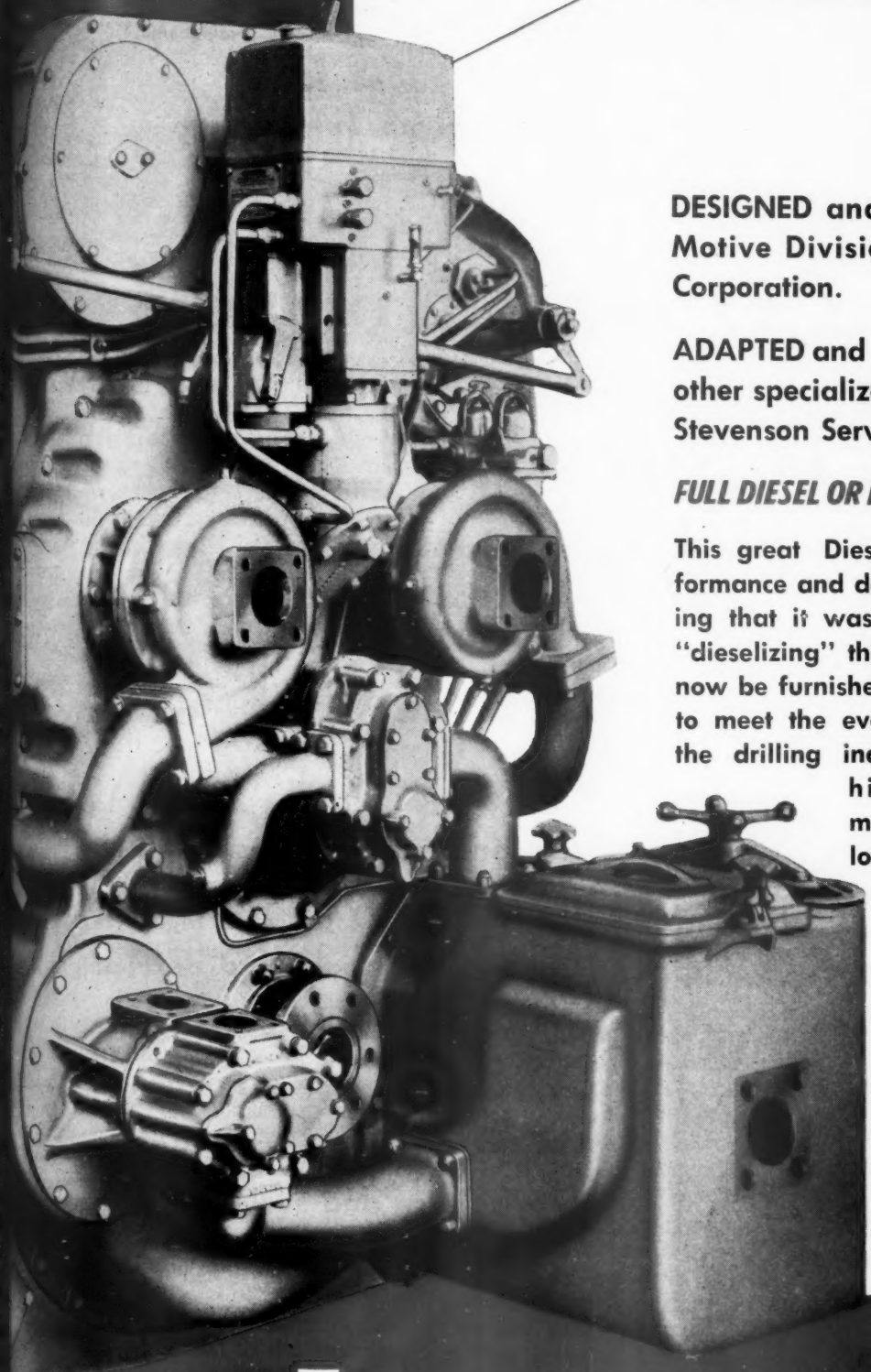

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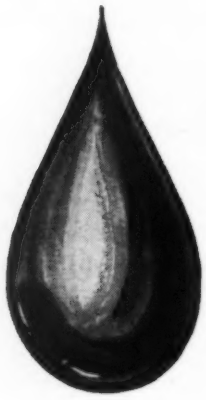

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Petroleum Engineering—A Progress Report

Material strides have been made; much remains to be accomplished

Primary objectives today are:

- Greater recovery of hydrocarbons
- Reduction in drilling costs

D. V. CARTER

PETROLEUM engineering, as such, is relatively young as a professional classification in the field of engineering.

It appeared on the horizon sometime during "the teens." About that time petroleum engineering was recognized in educational circles by the granting of degrees either in petroleum engineering or in some branch of engineering with a petroleum option. Many of the early petroleum engineers entered this field with various educational backgrounds, some from engineering and others with scientific preparation, such as geology.

In the beginning a petroleum (engineering) option, at least in some (several) schools, was a two-frontal affair. It could be taken either in the field of petroleum refining and processing, which included field processing of natural gas for the extraction of natural gas liquids, or it was available in the field of drilling and production. It is in this latter field that the term "Petroleum Engineer' has become known and recognized. In fact the use of the term "Petroleum Engineer" has diminished or disappeared from educational circles as well as from common usage. Chemical engineering, chemistry, and (chemical) process engineering have supplanted petroleum engineering in this phase of the petroleum industry. Therefore we know petroleum engineering today, in a broad sense, as engineering applied to the business in connection with drilling, production, and recovery of oil and gas.

Recovery as distinguished from production can very well be considered as planned, while ordinary production of oil and gas without the aid of extraneous energy or improved techniques can very well be termed as production that "comes naturally" or production that is obtained only with indigenous reservoir energy.

Higher percentage recovery of hydrocarbons together with a reduction in drilling costs for ever deeper drilling are the primary objectives of the petroleum engineer. The industry is badly in need of further improvement in these several categories. All else in the field of petroleum engineering is satellite in nature.

Substantial progress has been made in the field of petroleum engineering since its inception. Most of this progress has taken place within the span of the last 25 years. The past quarter of a century also coincides with the existence of *The Petroleum Engineer* magazine whose founding was amply justified as later proven by the marked progress and expansion of the petroleum engineering profession.

In order to record the progress and related events of petroleum engineering to the present time, an editorial board sponsored by the American Petroleum Institute is now engaged, with the help of various engineers in the profession, in the task of writing and publishing *The History of Petroleum Engineering*.

Although material strides have been made in petroleum engineering there remains much to be accomplished. We can expect the satisfactory solution of the more important problems provided members of the profession continue to exhibit sufficient interest and maintain their curiosity under favorable management and economic environment.

It is, therefore, obvious that the petroleum engineering profession is essential to the continued well being of the oil and gas industry. * * *

The Author

D. V. Carter is chief petroleum engineer of the Magnolia Petroleum Company. He is a graduate of Indiana University, where he studied geology, mining, and petroleum engineering. Employed by Magnolia, he organized the petroleum engineering department, and has been its head since its inception. He has been active in API and AIME work. In connection with the former he is a past chairman of the Southwestern District of the Division of Production (1943-44), and has served on numerous production committees. He became a member of the Committee on Reserves in 1943, was a member of the Ivy Committee (sub-committee on reserves and development of PAW District III Production Committee). He has also been active in the organization and promulgation of the cooperative type of field engineering committee. At present he is chairman of the API Division of Production Editorial Board, which is developing the "History of Petroleum Engineering." For AIME, Carter has served as vice president of the Production Review Committee. In addition to the activities mentioned, he is a member of many industry organizations and technical groups.

EXCLUSIVE

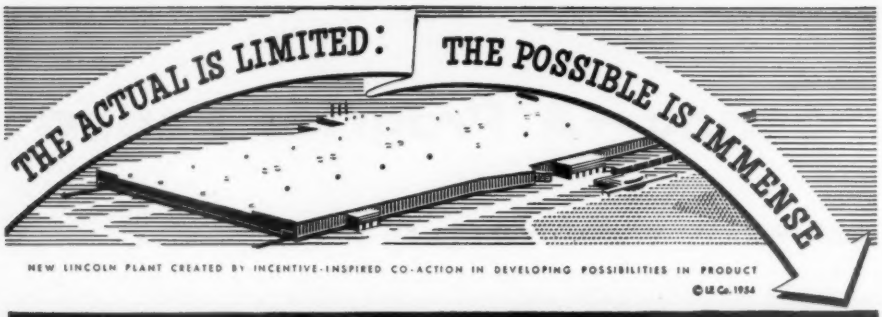
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Fig. 1. *Diesel-driven "Shield-Arc" welders on Linconditioning line. Welders are completely disassembled at start of rebuilding process.*

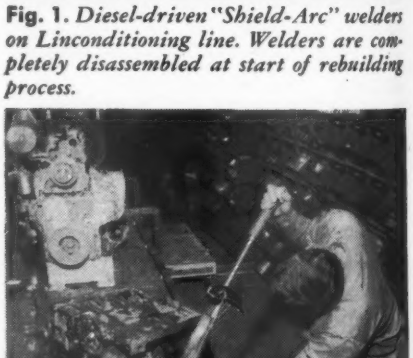

Fig. 2. *Welders are carefully reassembled on Linconditioning line. Rebuilt welders provide another full service life.*

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Where Will Future Oil Be Found?

Provinces presently considered attractive may be main sources because of competition from atomic energy

ROBERT R. WHEELER

IT WAS suggested that on the occasion of this 25th anniversary of *The Petroleum Engineer* we give our views on how and where oil might be found in another 25 years. It seems that geologists are always being asked to predict something, from the outcome of a drilling venture to global reserves, ever chided for a qualified answer, ever cursed for a bum guess. At least *that* situation will not change much in the next 25 years. Ask the investment expert in management about even the current probabilities of a stock market change, however, and try to decipher a tangible answer!

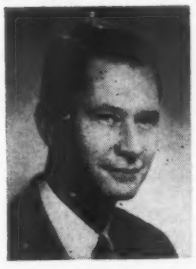
Midway in the 20th century we certainly have accumulated enough experience to predict that most of the prolific oil provinces of the world have already been tapped and that the basic principles and techniques of oil-finding are well established. We may find many new producing zones and vastly extend the productive portions of known provinces but it does not seem likely that the regions presently considered unattractive will add materially to the gross reserves, nor is it likely that entirely new techniques will appreciably affect discovery rate or ultimate production.

The Exploratory Record

The pattern of exploration established over several decades seems to indicate that more and more investment will be directed to exhausting the favorable known provinces and proportionately less to the current unattractive (though less explored) regions. With a few exceptions, it appears that after enough failures have been drilled to ascertain the favorable reservoir objectives and to test the more prominent trap possibilities of a region, it can be reasoned justifiably that some of the many unfavorable factors of geologic history are detrimental on a regional scale such that the reservoirs are inadequately sealed, or the oil flushed, or migration preceded the creation of traps, or a myriad of unfavorable possibilities have occurred relating source material, porosity, and time of migration.

The Author

Robert R. Wheeler is a consulting geologist in Dallas, Texas. Before becoming a consultant he had served in various geological capacities with oil companies in Texas and Oklahoma. His main contributions concern structural and stratigraphic problems in oil finding and Mid-Continent oil provinces, especially the Anadarko Basin. Wheeler has recently published a detailed structural map of Oklahoma for oil company distribution. He was educated at Johns Hopkins and Harvard (PhD 1942) and is listed in American Men of Science.



Similarly, the costs of exploration and exploitation in relation to profit may deter investment in some of the regions that currently appear, at least theoretically, potentially productive. For example, much conjecture is devoted to converting rough estimates of the sedimentary bulk of the continental shelves into future oil reserves on the entirely unproved and improbable assumption that these will be oil productive. But even if the continental shelves, e.g. bordering the Atlantic Ocean, should be oil-bearing like those of the Gulf of Mexico (not indicated in any manner by exploration to date) there is still the overwhelming expense of production to reckon at a turning-point in the history of fuels.

Inevitability of Atomic Power

It seems at this stage, on the threshold of atomic power, that large portions of the less accessible and less attractive oil potential might as well not exist (insofar as of practical interest to oil operators) and that in the next few decades atomic energy for large power requirements may be cheaper than power from petroleum. This development seems implicit in the planning, research, and announcements of federal and private agencies involved in atomic projects.

The Independent Operator

If it is reasonable to predict that exploration will become concentrated in the more favorable regions, particularly in North America where the great majority of competing producers must operate, it seems probable that the independents will be responsible for an increasing proportion of the discoveries and ultimate recovery. The independent, operating with a minimum overhead and adequate technical staff basically interested in profitable operation, can compete far more successfully with the major companies now than in the past because:

1. The independent has benefited by the general improvement and dissemination of knowledge regarding techniques of oil finding.
2. Where single companies can or once could tie-up large lease blocks, there is a definite tendency for division of leases and multiple ownership with more competitive acquisition in response to increasing awareness of mineral values among both operators and royalty owners.
3. The independent reaps the maximum rewards from the tax benefits to the oil industry by the promotion of highly taxed outside investors, trading in leases and minerals, drilling up year-end profits, selling production as long term gain and, in general, obtaining through flexibility of operation, profits beyond those permittted by integrated company practice; whereas, the profits of refining and marketing will attract producers or groups of producers with sufficient capital and technology.

It looks as though a pattern had been established in which the companies of greatest resources tended to initiate

EXCLUSIVE

TABLE 1. Probability and profitability factors.

		Probabilities of Accumulation	
		Favorable	Doubtful
TRAP	Closure	Provable closure with relief in excess of thickness of oil objective; proof of critical dip on flank of anticline opposed to regional tilt; test is located with reference to gas-oil-water levels. Proof that closure is adequate to have retained oil; evidence of a seal to vertical migration. Proof that fault "Trap" is a seal—not a thorofare for up-dip migration. Beware the "bootleg" seismic map, the surface "high" in evaporite terrane, the subsurface prospect contoured on "estimated" datums!	Closure can only be inferred from interruption in Regional dip, or from multiple shows in a high well, or from inadequate seismic control; structural position is uncertain with reference to nearby levels of gas oil and water; reservoir may be depleted by old production, flushed by natural water flooding or drained by early geologic movements; reservoir beds are transitional upward in permeability; fault displacement could juxtapose porous zones allowing through migration of oil and gas; map datum and oil objective are separated by an unconformity.
	Wedge-edge	Wedge-edge accurately delineated; test located in a favorable structural position with respect to gas, oil and water levels and pay thickness. Porosity of a wedging reservoir may have been improved by truncation and subaerial leaching or by sorting of an onlapping objective. Effective seal to vertical and up-dip migration.	Direction and rate of convergence uncertain; structural position of test with relation to wedge-edge, pay thickness or fluid content is doubtful. Porosity may be affected adversely by convergence factors, cementation or diagenesis; transitional vertical permeability may indicate unfavorable connate water saturation and poorly sealed reservoir rocks.
OBJECTIVE		Proof of a thick porous reservoir objective which is consistently developed, and the prospect lies within the producing trend of this specific reservoir.	Variations in porosity and pay thickness approach the minimum economic limits of development; pay may wedge-out across structurally high prospect.
		Profitability Considerations	
		Income	Expense
ECONOMICS		Crude and gas price, oil gravity, gas-oil-water saturation, per acre recovery, well spacing, productive reservoir area, allowables, pay-out, depletion.	Acreage bonuses, commissions, royalties, oil payments; exploration expense; drilling, testing, equipping, and producing costs; taxation.

major exploratory programs to evaluate sub-provinces within the known favorable regions eventually followed by increasingly competitive lease acquisition and more economical operation of the independents. We currently observe varying stages of this trend in the remarkable 20 per cent wildcatting success in intensely explored areas of the Mid-Continent conducted largely by independents in contrast to the less advanced stages of primarily major company exploration of, for example, the Williston Basin.

As subsurface control accumulates and farmout acreage becomes more available the independents, hedging greater dry-hole risks by contributions and sale of interests, gradually dominate the drilling and discovery picture. Obviously, the individual fortunes possible from small leases will always attract risk-capital when such reserves have long since failed to meet major company crude requirements.

Importance of Tax-Money

These considerations involve one of the remarkable developments in the search for petroleum—the increasing importance of tax-money investments from outside the industry and the need for greater prudence as this money is invested by independent promoters. Those of us who deal principally with the independents are sometimes amazed by the kind of prospect and divisions of interest undertaken in these tax money-operator relationships. Undoubtedly the industry benefits by the introduction of such risk capital because it permits more wildcat wells to be drilled and tests proportionately greater areas of competitively owned acreage and unanticipated petroleum reserves. If so, it would seem good business to provide these investors with the greatest reasonable chance to profit; yet, it often appears that tax-money is promoted into ventures that would not conceivably attract the operator's personal investment.

Oil Is How You Find It*

This is the situation in which that salt-caked adage "oil is where you find it" and its corollary "you can't tell 'til you drill it" (with the intent of implying that oil finding is pure luck) becomes an offense to human intelligence. If there is any one crucial observation derived from the last 25 years of drilling that should govern our future exploration, it is fact that the best record of discovery is made through utilization of combined geophysical and geological techniques. In fact, where subsurface control is reasonably abundant and reflection seismic mapping is combined, the odds of discovery will be appreciably better than the present excellent 20 per cent record (by all methods) of many currently active oil regions. This is true because most of the prerequisites for petroleum can be ascertained in advance of drilling; so many, in fact, that approximations as to the quality of reservoir objective, drilling and completion cost, and other economic factors permit some choice as to the class of prospect in terms of both chance of success and degree of profit (Table 1).

Thus, depending upon the capital outlay and the odds of success, it seems only reasonable to provide the investor with a share in enough ventures to expect a profit, even if it means confining operations to shallower less prolific objectives or spreading the capital further by additional sales of partial interest.

In other words, by whatever means the independents, who seem destined to play an increasingly important part in the exploitation of the remaining economically accessible reserves, are financed, they will succeed in the long run in proportion to their ability to screen prospects and play the long term odds against the success of any individual venture. Judging from how oil is being found, the next quarter century may witness the demise of the doodle bugger, the not-so-educated hunch and the dry-hole profits because it looks as though the competition will get tougher. * * *

*Wheeler, Robert R., "Oil Is How You Find It," *World Oil*, October, November, 1951.

"Greatest Power Plant on Earth"

Dr. Charles F. Kettering, internationally-famed inventor and scientist, in a talk to the National Petroleum Association said that the American people can depend on the cooperation of the oil and automotive industries "for the best rubber-tired transportation anywhere at the lowest possible cost."

Dr. Kettering told the oil men that normal business requires planning of at least 5 to 10 years ahead, while research and development requires at least 15 to 20 years.

The director and research consultant for General Motors Corporation said the nation's 55,000,000 automobiles represent the greatest power plant in the world. Tremendous strides have been made in fuel and lubricants since the war. "You fellows in the oil business have done a wonderful job," he said.

Referring to the automotive industry, Dr. Kettering said their designers were "trying to raise the ratios of engines as fast as you fellows can raise the octanes.

"I've been asked at times why we are trying to do this; whether it really means anything," he said. "The answer is very simple—with a 12 to one ratio, you can get twice as much mileage from the same amount of gasoline. That's getting the most out of our resources."

Our interests are the same

...getting your well down in shortest possible time!

HUGHES research and the combined efforts of the HUGHES field organization* have *one purpose*... giving you bits that will get your well down in the least possible time... and at the least possible cost.

The HUGHES man responsible for servicing your rig knows from actual field experience the bits that will give you the fastest penetration and most footage in the formations you are likely to encounter. And you can depend on him to have the right bits on your rig at the right time.

* *A field organization of over 400 serves the industry in the United States and Canada*

Penetration's wonderful

but this is KONESHOT

shaped-charge perforating

KONESHOT is Lane-Wells own shaped-charge perforating—the service which gives you all the deep penetration of regular shaped-charge perforation **plus** the pin-point accuracy of Lane-Wells famous depth measurement system. Deep penetration is great stuff, all right, but it's much better when it's delivered in the exact place you specify. And that's what **KONESHOT gives you!**

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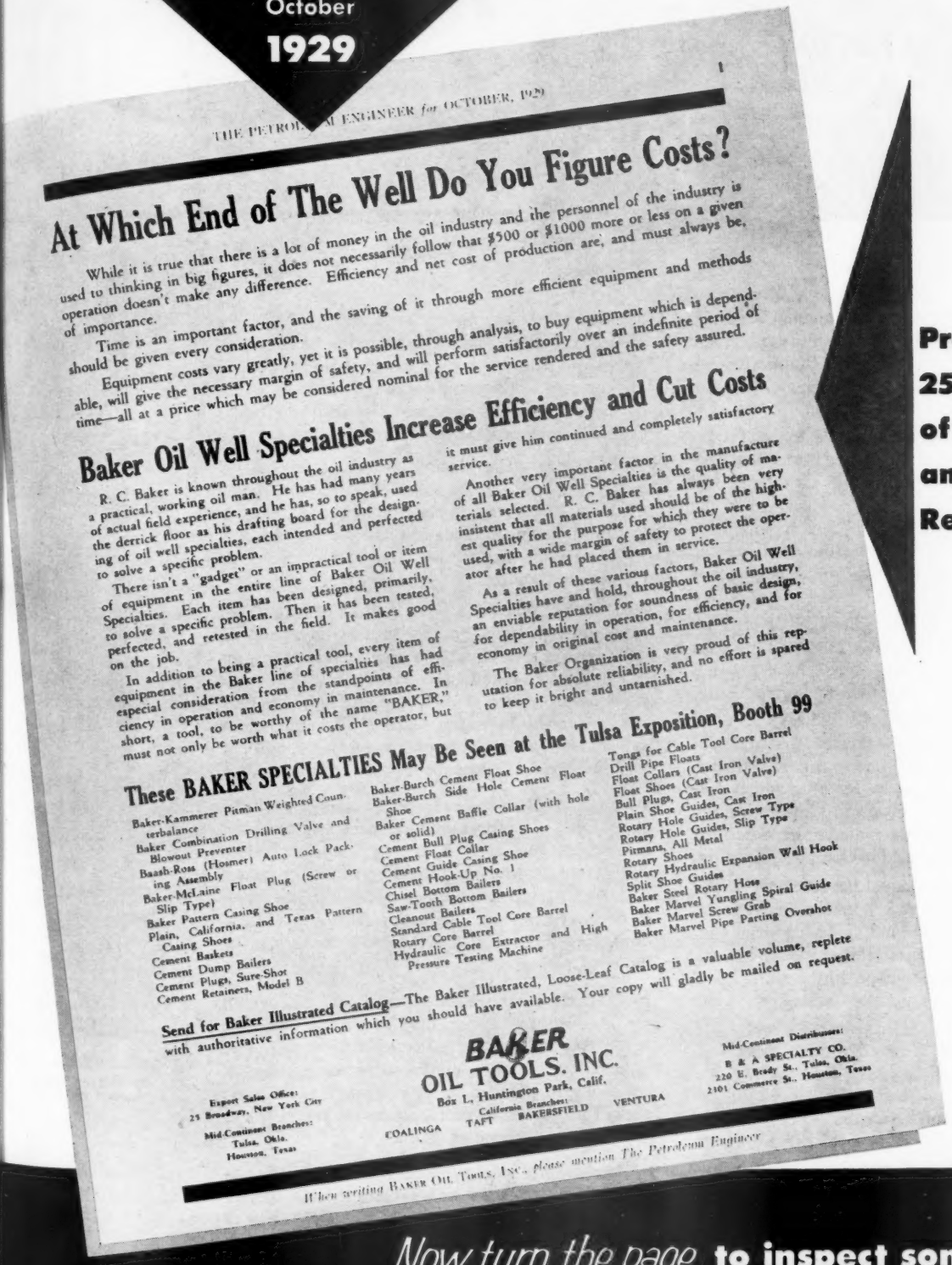
A lot can be done in 25 YEARS if you work at it!

The Baker Advertisement in the FIRST Issue of THE PETROLEUM ENGINEER October 1929



THE PETROLEUM ENGINEER for OCTOBER, 1929

At Which End of The Well Do You Figure Costs?

While it is true that there is a lot of money in the oil industry and the personnel of the industry is used to thinking in big figures, it does not necessarily follow that $500 or $1000 more or less on a given operation doesn't make any difference. Efficiency and net cost of production are, and must always be, of importance.

Time is an important factor, and the saving of it through more efficient equipment and methods should be given every consideration.

Equipment costs vary greatly, yet it is possible, through analysis, to buy equipment which is dependable, will give the necessary margin of safety, and will perform satisfactorily over an indefinite period of time—all at a price which may be considered nominal for the service rendered and the safety assured.

Baker Oil Well Specialties Increase Efficiency and Cut Costs

R. C. Baker is known throughout the oil industry as a practical, working oil man. He has had many years of actual field experience, and he has, so to speak, used the derrick floor as his drafting board for the designing of oil well specialties, each intended and perfected to solve a specific problem.

There isn't a "gadget" or an impractical tool or item of equipment in the entire line of Baker Oil Well Specialties. Each item has been designed, primarily, to solve a specific problem. Then it has been tested, perfected, and retested in the field. It makes good on the job.

In addition to being a practical tool, every item of equipment in the Baker line of specialties has had especial consideration from the standpoints of efficiency in operation and economy in maintenance. In short, a tool, to be worthy of the name "BAKER," must not only be worth what it costs the operator, but it must give him continued and completely satisfactory service.

Another very important factor in the manufacture of all Baker Oil Well Specialties is the quality of materials selected. R. C. Baker has always been very insistent that all materials used should be of the highest quality for the purpose for which they were to be used, with a wide margin of safety to protect the operator after he had placed them in service.

As a result of these various factors, Baker Oil Well Specialties have and hold, throughout the oil industry, an enviable reputation for soundness of basic design, for dependability in operation, for efficiency, and for economy in original cost and maintenance.

The Baker Organization is very proud of this reputation for absolute reliability, and no effort is spared to keep it bright and untarnished.

These BAKER SPECIALTIES May Be Seen at the Tulsa Exposition, Booth 99

Baker-Kammerer Pitman Weighted Counterbalance
Baker Combination Drilling Valve and Blowout Preventer
Baash-Ross (Hosmer) Auto Lock Packing Assembly
Baker-McLaine Float Plug (Screw or Slip Type)
Baker Pattern Casing Shoe
Plain, California, and Texas Pattern Casing Shoes
Cement Baskets
Cement Dump Bailers
Cement Plugs, Sure-Shot
Cement Retainers, Model B
Baker-Burch Cement Float Shoe
Baker-Burch Side Hole Cement Float Shoe
Baker Cement Baffle Collar (with hole or solid)
Cement Bull Plug Casing Shoes
Cement Float Collar
Cement Guide Casing Shoe
Cement Hook-Up No. 1
Chisel Bottom Bailers
Saw-Tooth Bottom Bailers
Cleanout Bailers
Standard Cable Tool Core Barrel
Rotary Core Barrel
Hydraulic Core Extractor and High Pressure Testing Machine
Tongs for Cable Tool Core Barrel
Drill Pipe Floats
Float Collars (Cast Iron Valve)
Float Shoes (Cast Iron Valve)
Bull Plugs, Cast Iron
Plain Shoe Guides, Cast Iron
Rotary Hole Guides, Screw Type
Rotary Hole Guides, Slip Type
Pitmans, All Metal
Rotary Shoes
Rotary Hydraulic Expansion Wall Hook
Split Shoe Guides
Baker Steel Rotary Hose
Baker Marvel Yungling Spiral Guide
Baker Marvel Screw Grab
Baker Marvel Pipe Parting Overshot

Send for Baker Illustrated Catalog—The Baker Illustrated, Loose-Leaf Catalog is a valuable volume, replete with authoritative information which you should have available. Your copy will gladly be mailed on request.

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When writing BAKER OIL TOOLS, INC., please mention The Petroleum Engineer

Proved by 25 Years of Service and Successful Results

Now turn the page **to inspect some of the outstanding BAKER Products offered October, 1954**

XUM

BAKER *Tools for Today's Operations*

BAKER OIL TOOLS INC. — BAKER — SERVING THE WORLD

Here are a few of the most outstanding Baker Oil Tools for 1954. Complete details, illustrations and specifications are in your new 1954 Composite Catalog, starting on Page 435, where many other important Baker Products will be found.

▶ No other product has proved so successful for so many applications as the BAKER RETAINER PRODUCTION PACKER, which can be set on tubing, drill pipe, or on a wire line. Look on Page 496 of the 1954 Composite Catalog to learn how it is used for single-zone or dual-zone production; as a squeeze tool for acidizing or cementing; as a tubing anchor and as a bridge plug.

▶ For placing cement slurry, plastic, acid or other fluids, the BAKER RETRIEVABLE CEMENTER provides a safe, positive "Hold-Down Type" Packer which operates mechanically rather than by fluid pressure. Look on Page 495 of the 1954 Composite Catalog.

▶ BAKER CASING BRIDGE PLUGS can be set on tubing, drill pipe, or on a wire line to provide either a permanent or a temporary bridge plug which prevents either upward or downward movement of fluid or gas. Many other advantages are described starting on Page 474 of the 1954 Composite Catalog.

▶ No other product can equal the efficiency of the BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE for safely floating-in and landing casing strings of any length. Removes bridges, washes the formation, and imparts a "whirling" action to the slurry. See Page 438 of the 1954 Composite Catalog.

▶ With BAKER DIFFERENTIAL FILL-UP SHOES (or Collars) the casing is filled automatically as it is being run, to within 90% of the fluid level of the annulus. Eliminates the dangerous "Ram Effect" which may break down a potential lost-circulation zone. Permits the introduction of the action of a back-pressure valve at the discretion of the operator, for floating (if desired) and for cementing. Ask any Baker office for brochure containing complete details.

▶ BAKER FLEXIFLOW FILL-UP SHOES (or Collars) permit filling the casing automatically as it is being run, while maintaining a relatively constant level of dry (unfilled) casing until the casing has been landed. It is then possible to bring the Bakelite Ball Valve into play as a back-pressure valve for floating and/or cementing when desired. This latest Baker development is illustrated and described in a folder available upon request from any Baker office.

▶ For successfully placing cement or fluid at the place where it will be most effective, the BAKER CEMENT RETAINER has been "standard equipment" in International oil fields for many years. Read of its many uses starting on Page 474 of the 1954 Composite Catalog.

▶ The importance of having the I.D. of casing free from gun-shot burrs, hardened rotary mud and mill scale is evident from the rapidly increasing use of BAKER ROTO-VERT CASING SCRAPERS. Can be run easily and safely on drill pipe, tubing or a wire line, and leaves the "working surface" of casing clean and smooth for all future operations. Look on Page 517 of the 1954 Composite Catalog for details.

▶ When the time comes to center casing *positively*, and provide a uniform annular space for successful cementing, you need BAKER HINGE-LOK CASING CENTRALIZERS. Made in four ranges to exactly meet your casing programs, with many features not found in other centralizers. Interesting facts and illustrations start on Page 462 of the 1954 Composite (or Baker) Catalog.

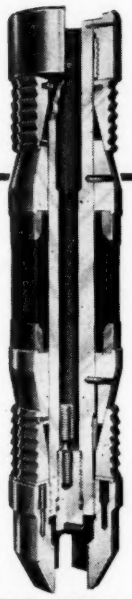
▶ Controlled removal of the mud cake throughout the intervals to be cemented is positive and safe when BAKER WALL SCRATCHERS are used. The "scratching" action is minimized while running-in, but the spring-loaded wires with maximum reach dig in for best results on the upstroke. See Page 472 of the 1954 Composite Catalog.

▶ Any drilling man will tell you how the BAKER DRILL PIPE FLOAT VALVE lengthens the life of wire lines and brake bands by relieving weight; how it prevents pulling "wet" strings; how it prevents or minimizes accidents in case the drilling string should part. See for yourself on Page 534 of the 1954 Composite Catalog.

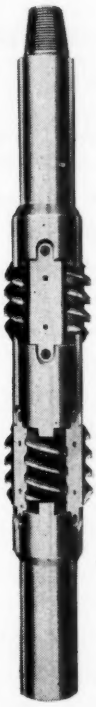
Baker Retainer Production Packer
Product No. 415-D

Baker Retrievable Cementer
Product No. 411-RT

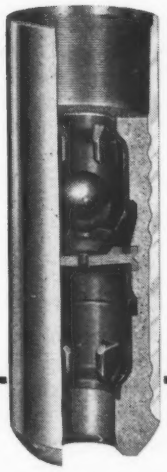
Baker Cement Wash-Down Whirler Float Shoe
Product No. 120



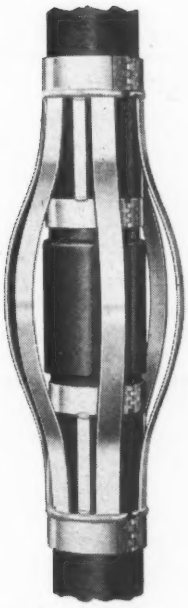
Baker Wire Line Bridge Plug
Product No. 400-N



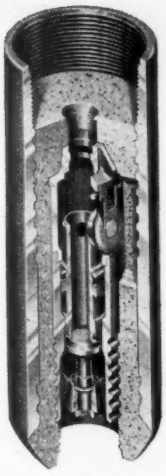
Baker ROTO-VERT Casing Scraper
Product No. 620-C



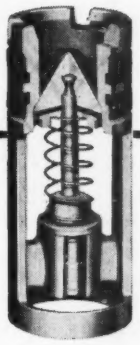
Baker FLEXIFLOW Fill-Up Shoe
Product No. 160



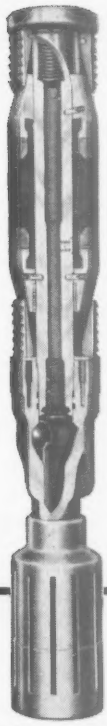
Baker HINGE-LOK Casing Centralizer (H-25)
Product No. 9113



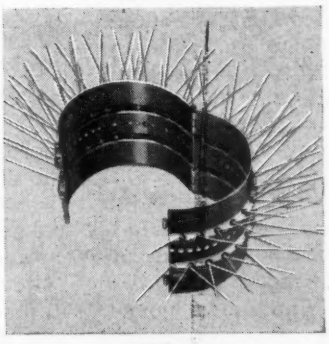
Baker Differential FILL-UP Shoe
Product No. 1081



Baker Drill Pipe Float Valve
Product No. 4813

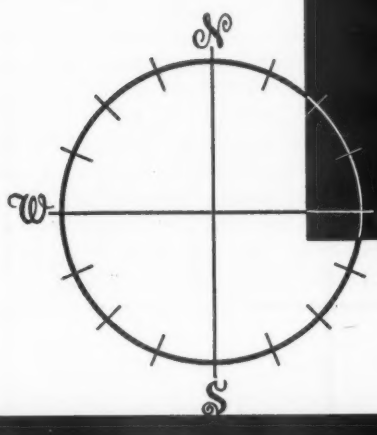


Baker Cement Retainer
Product No. 400



Baker Wall Scratcher
Product No. 900

The Baker Section starts on Page 435 of your 1954 Composite Catalog; or if you prefer a separate BAKER Catalog, contact the office nearest you.



BAKER

OIL TOOLS, INC.

HOUSTON • LOS ANGELES • NEW YORK

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Cuban-Canadian Pact

Cuban-Canadian Petroleum Company, Ltd., of Wilmington, Delaware, has signed an agreement with a group of Cuban petroleum executives for oil exploration on 4,992,700 acres of Cuban oil land. The area covered borders at one point on the new discovery well brought in last June in Camaguey Province. One part of the new Cuban-Canadian 30-year lease is within 400 yd of the Jatibonico wildcat now yielding approximately 150 bbl of oil daily. Drilling on new Cuban oil lands will begin within 90 days.

★ ★ ★

Alaskan Report Available

The USGS has completed and made available for inspection in Washington, D.C.; San Francisco, California, and Anchorage, Alaska, a geological report and map of the Malaspina district of Alaska and the adjoining petroliferous province. Numerous oil seeps, some of high gravity crude, have been reported in the area. Over 2,000,000 acres of Federal bases are granted or applied for and drilling operations are in progress in the Phillips-Kerr-McGee holdings in the northwestern part of the province.

★ ★ ★

Scholarships Are Awarded

Twenty-three sons and daughters of Cities Service Oil Company employees have been awarded scholarships by the Henry L. Doherty Educational Foundation, a Cities Service supported organization. The scholarships will be applied at a college selected by the student. Renewed scholarships were also granted to 33 additional students enabling them to continue their college studies.

★ ★ ★

Form Producing Subsidiary

The incorporation of Mobile Producing Company, wholly owned subsidiary of Socony-Vacuum Oil Company, Inc., has been announced. The new company will take over the operations formerly handled by the Pegasus division of Socony-Vacuum and conduct exploration and producing operations in the U. S. portion of the Williston Basin and in the northern Rocky Mountain area. Headquarters for Mobile Producing Company will be in Billings, Montana.

Ham Gossett Rules Set

Railroad Commission, after hearing in Austin, has established operating requirements for the Ham Gossett field of Kaufman County, Texas, prolific recent fault line discovery in the Mexia Talco trend. Chief among regulations are 20-acre spacing in Woodbine, and 1000 ft GOR limit. Allowable is to be based 75 per cent acreage and 25 per cent well.

★ ★ ★

AAODC California Meet Set

Annual convention of the nations Drilling Contractors is scheduled to be held in Los Angeles this year. Meeting dates are October 11 through 13, with an association sponsored ocean cruise to follow for those desiring. Meeting will be highlighted by the array of excellent papers planned and by the outstanding social program that has been announced. In this latter connection, the annual suppliers party is expected to be outstanding.

★ ★ ★

French Oil Strike

Esso Standard of France has reported the completion of the second well in the Les Landes area, a strip of barren sand and scrub pines along the shore of the Bay of Biscay. Potentialled and producing at a rate of 2400 bbl a day, the second well and the discovery well, which is flowing 3000 bbl per day are presently producing almost as much oil as the rest of the country combined. The operators have not made a public estimate of the potentialities of the area, feeling that it will be necessary to drill several more wells before the proper evaluation can be made.

★ ★ ★

Petroleum Meet Slated

The program for the 18th annual conference on petroleum production at Pennsylvania State University October 6-8, will include eleven papers on technical aspects of petroleum production by secondary recovery methods. Event attracts oil men from most of the oil producing states.

The Pennsylvania Grade Crude Oil Association, which maintains a production research laboratory in Bradford and has sponsored petroleum research for many years at Penn State, is cooperating in the conference.

Research Expanded

The Texas Company has implemented a substantial expansion of its research and technical activities by establishing an independent research and technical department and expanding its research facilities at the company's principal research laboratory at Beacon, New York.

Research and technical department will carry on a broad research program ranging from basic work in physics, chemistry, and engineering to the continuous development of new products and processes. In addition, it will also provide a variety of technical services to the sales and refining departments.

★ ★ ★

United Geophysical Sold

Union Oil Company of California has sold the assets of the United Geophysical Company, Inc., to a group of employees of the geophysical company headed by C. C. Lister, president, and E. A. Pielemeier, vice president.

Union Oil purchased the geophysical firm in 1950. Its sale is announced as being in line with the company's policy of encouraging and stimulating the growth of independent businesses.

CLIP YOUR OWN DRILLING MANUAL

When completed the Drilling Fundamentals series now being published in The Petroleum Engineer will be a valuable and comprehensive handbook of rotary drilling.

Don't miss clipping the installments in each issue. The pages fit standard loose-leaf notebooks.

Drilling Fundamentals will include 55 articles written by those who know drilling operations and can describe them. Turn to **Page B-126** now and clip this month's chapters on **Drilling Fundamentals.**

What's New Tomorrow?

- *Deeper wells*
- *More efficient completions*
- *Greater reservoir recoveries*

All can be foreseen in the near future

SIM H. CREWS*

Portability and move efficiency rank high in modern rig requirements.

WHERE leads the path to the future? The task assigned the discoverer and producer of crude oil and natural gas seems clear. Historically the nation has seen an ever-increasing demand for his product with the coming of each new day. True, there have been and will probably continue to be minor fluctuations in this demand, but the trend has been an increasing one. In 1929, birth year of *The Petroleum Engineer*, the combined domestic and export demand for United States crude was for slightly more than 3,000,000 bbl a day. The depression reduced this to a low point in 1932 of 2,500,000 bbl. With few exceptions since this low was passed, each year has seen a steady improvement in the demand for petroleum and its products until in 1953, the staggering total of 2.9 billion bbl, over 8 million bbl a day, was used.

To say that natural gas has followed a parallel course would be, indeed, minimizing the gains reported for this valuable commodity. From a low of some 2 trillion cubic feet per year used in the depth of the depression, the consumption of natural gas has more than quadrupled with nearly 9 trillion cubic feet of natural gas being delivered to ultimate consumers in 1953.

Use of petroleum and natural gas is logically portrayed and gains emphasized through the device of expressing their contribution toward satisfaction of the total national energy requirements. In 1929, of the total U.S. energy needs, crude oil supplied 25 per cent and natural gas 9 per cent. That year coal was by far the greatest supplier of energy. Contrast this, then, with the figures for 1953, when crude oil supplied 41 and gas 23 per cent of a greatly increased total demand.

What has happened to our known reserves during this period of tremendously accelerating uses? Have they declined? Have they approached the vanishing point as many responsible men have predicted they would? The obvious answer to these is, of course, no. Our reserve picture today is stronger than at any time in our history. Here we are faced with a paradox seldom equaled. The more petroleum we use, the more we have available. Starting with some 12 billion known bbl in 1929, we have used to our hearts' content and have remaining now almost 3 times as much as we had then.

These few facts serve well to show the future course of oil and its partner, natural gas. The question of the path ahead can have but one answer and that an optimistic one. The future must bring forth in continued abundance the bounties of nature which are the fruits of the oil man's efforts, the product of men and materials, of tools and techniques. To realize how this will be brought about, let us review briefly the progress of the last 25 years in the industry.

Rotary Drilling

Average well depth in 1929 was 2897 ft. That year saw the completion of almost 27,000 holes, a level that was not to again be reached until 1937. It also witnessed a new depth record, 9280 ft, but one destined to be typically temporary in this vital industry, and which scarcely lasted out the year.

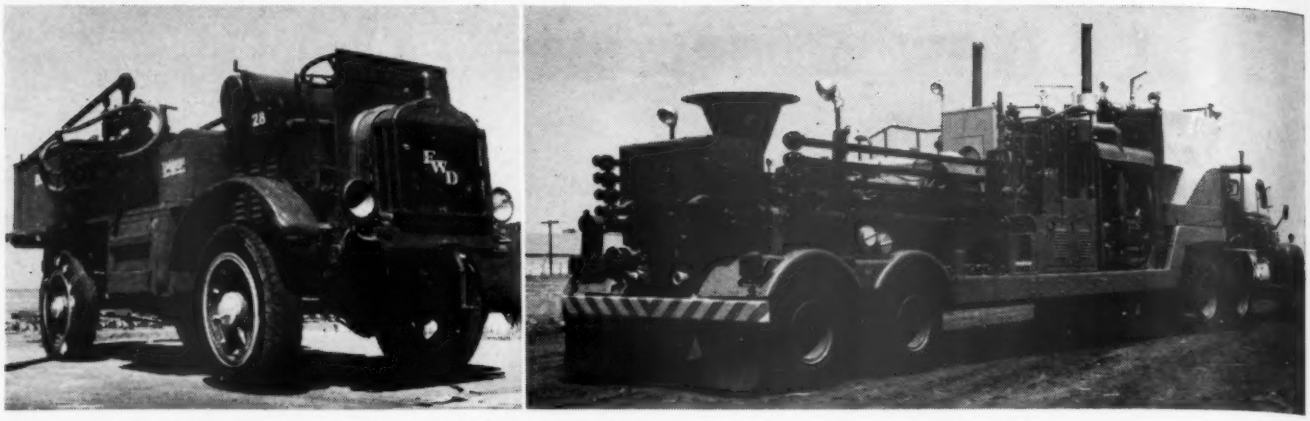
Rotary drilling rigs of the period were, indeed, a far cry from our modern machines, though much credit must be given the men who operated them, and nothing but admiration is due the results achieved with such rudimentary equipment.

It was still a period of "iron men and wooden derricks" for the most part. A few steel drilling and combination derricks were in use and their wide-spread acceptance was a foregone conclusion but the early day wooden structures were certainly not the novelty they are today.

Rig power was provided almost entirely by steam with a few electric rigs employed in development drilling. The first power (internal-combustion engine) rigs appeared in the early thirties. Relatively crude affairs, they were basically heavy duty pulling machines adapted to drilling service. Power transmission by chains and jaw clutches gave undesirable operating characteristics—power application, instead of being smooth and even as with steam, was very rough and operating personnel customarily referred to these early power rigs in most uncomplimentary terms. They did, however, have one thing in their favor over steam—mobility. They represent one of the earliest approaches to the modern unitized rig and did much to force development along this line. Today, of course, the power rig is the accepted drilling machine generally. The modern steam rig is an excellent tool offering wide flexibility in application of

*Editor, Exploration, Producing, and Drilling Edition.

EXCLUSIVE



Cement Truck No. 28, adequate for the wells of its time, would be hard pressed to compete with today's equipment.

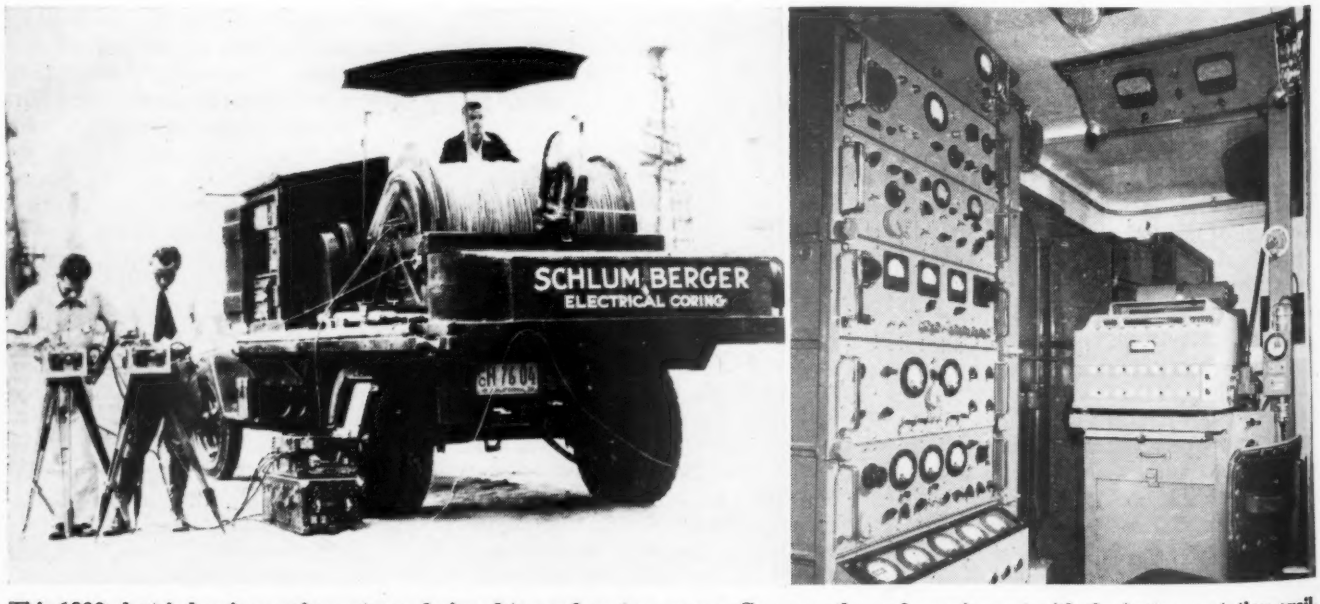
power, and generally is considered an ideal means of drilling. Even with the present-day improvement in its transportability, however, the steam rig generally requires a great deal of high priced fuel, and its water consumption is too great for it to effectively compete with the power rig in most areas.

Tremendous strides in the development of the power rig are evident. The compounding transmission, permitting the application of several engines to either the draw works, pumps, or rotary table, was an early development that contributed much to present-day equipment. Air clutches replacing the earlier jaw clutches added greatly to both smoothness and ease of operation.

Not limited solely to power rigs were the hydromatic brake, a development that became common in the mid-thirties, and the water-cooled break drum. Prior to the advent of this equipment, round trips from any considerable depth were apt to be rather lengthy affairs characterized by frequent waiting periods while brakes were taken up and allowed to cool off.

The late forties and early fifties have brought to today's high state of development the modern methods of power transmission, the fluid coupling, the hydraulic torque converter, and the electro-magnetic coupling, and have seen their widespread acceptance by industry. Coincident with these developments has been the introduction of the high horsepower mud pump. At the time *The Petroleum Engineer* was founded and dedicated to the furtherance of engineering knowledge and its dissemination and application to practical oil field use, power mud pumps were relatively light and ineffective devices in the light of modern thinking. Drilling mud was primarily the result of making hole with clear water in those days, though a few drillers had begun to realize its importance in the drilling operation, and occasionally sought a nearby surface clay pit whose product could be used to improve the consistency of their drilling fluid. It was after World War II that the importance of fluid hydraulics in drilling received widespread recognition. At this time, the industry began to see big improvements in the capacity of power pumps and operations, utilizing the the latest developments in chemical drilling fluids and pumps in the 700-hp range, became commonplace.

Another development in recent years is the acceptance of long strings of heavy drill collars. Early day operators customarily drilled relatively large holes, 12 in. or more, and used large size drill pipe. One popular combination of the early thirties was 12¼-in. hole and 6⅝-in. drill pipe. With increasing depth, this heavy pipe placed an uneconomic load on available hoisting equipment, additionally retarding drilling rates. Operators then attempted to improve performance with smaller holes and lighter drill pipe with the result that 3½-in. and 4½-in. drill strings and 7⅞-in. to 9-in. holes became approximately standard. The original drill collar was actually a short combination coupling with a drill pipe box on one end and a bit pin box on the other. Reduction of drill pipe diameter and weight forced the redesign of the



This 1932 electric logging equipment was designed to produce two curves. Compare the early equipment with the instrumentation available in 1954.

Cased hole logging and gun perforating have come a long way in the time interval presented by these two pictures.

early drill collar into the heavy tube, usually 30 ft in length, common today. A better understanding of drilling requirements, the almost universal acceptance of the rock bit for most normal types of drilling, and the drilling of increasingly hard formations at greater depth all worked to force the operators into the practice of using several of these drill collars, sometimes as many as 20 or more.

The so-called "rock" bit has today almost surplanted the older "three-way" and fishtail bits even for drilling the soft shales of the Gulf Coast. This evolution is the product of a combination of improved rock bit design from a standpoint of tooth pattern, bearing capacity, and metallurgy, and the practice of carrying heavier bit loading while drilling. The change was also materially influenced by the increased understanding of fluid hydraulics and the use of modern-day chemical muds.

The coring operation has seen improvement comparable to that transpiring in other techniques also. From the early-day shop-made devices made of drill pipe and resembling superficially an elongated wash-over shoe to the modern wire line retrievable barrel is a long step. Available today for all important core recovery in extremely hard rock country are excellent diamond core heads and for softer coring we have both roller and blade type heads. Improved techniques and equipment have added greatly to the percentage recovery enjoyed by modern operators.

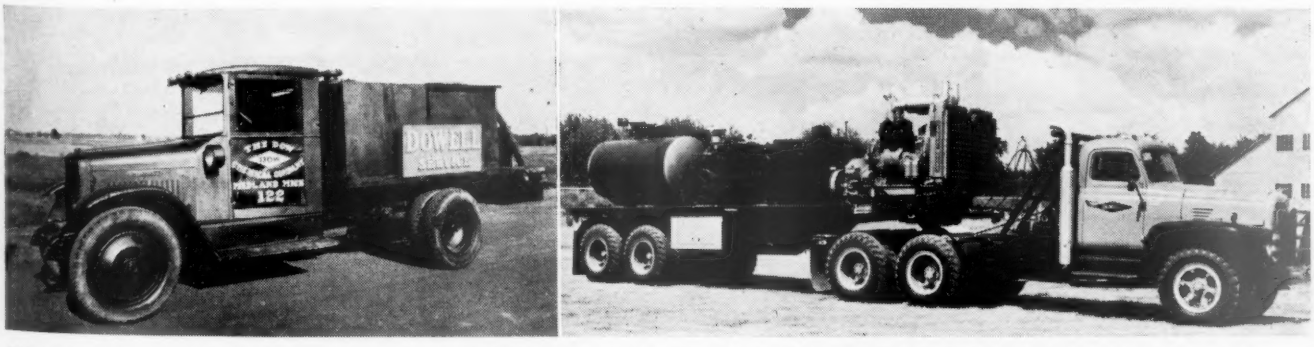
Last year (1953) the industry drilled nearly 50,000 wells at an average depth of slightly over 4000 ft. From the 1929 record of 9280 ft, the oil seeking bit has driven to a new level of 21,482 ft. These facts illustrate the progress the last 25 years have brought to oil-well drilling, and indicate well the trend for the future. It is quite obvious that, economic conditions remaining healthy, we shall drill increasingly deeper wells, more wells, and to a greater average depth, at least in the immediate future.

Many problems remain to be solved. Two of them, lost circulation and crooked holes, are of particular importance. As our wells go deeper the hydrostatic head due to the long column of drill mud reaches staggering proportions, particularly if heavy muds are used because of anticipated high formation pressures. Though considerable progress has been made in controlling loss and restoring circulation, much remains to be accomplished in this field. Crooked holes offer another challenge to the drilling man. In some sections of the country, the inclination and texture of formations make their penetration without excessive hole deviation most difficult. Improvement in this operation has been apparent also but here again much work remains to be done.

Penetration rates, particularly in areas of extremely hard rock, need and undoubtedly will receive, improvement. The tungsten carbide insert chert bit is an excellent example of the development of special tools to improve drilling efficiencies. Use of two cutter jets for better performance in softer drilling is an equally good illustration and of comparable importance. In the line of the newer tools, the sonic drill and the sub-surface turbine both offer promise for improving penetration rates, particularly in hard rock drilling and in crooked hole country.

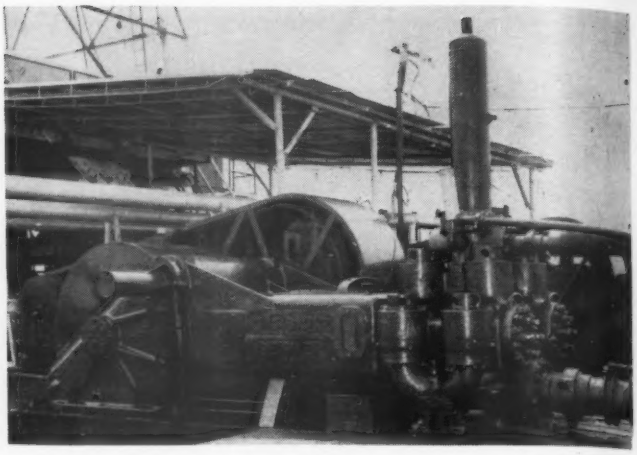
The drilling industry's record toward improving penetration rate in the last eight years is impressive. The AAODC estimates that, since 1946, drilling rates have increased almost 50 per cent. Through contractors' costs have practically doubled in recent years, the improved drilling rates achieved through application of fluid hydraulics, increased bit weight, better mud, and improved techniques, enable him to deliver hole to the operator today as cheap or cheaper than he did 15 years ago.

Rig mobility is of vital importance in the drilling field. Though not a major problem, with competition at its present level, every effort to reduce drilling cost is justified and a reduction in rig moving cost offers a partial means toward this end. It may be that the future will see rigs more nearly designed for specific jobs in selected areas. Exploration work may be handled by light, highly mobile equipment designed for drilling small holes to depths of 10,000, 12,000, or 15,000 ft, while development drilling is done by heavier machines. Barges and platforms will undoubtedly play a major role with the impending offshore opera-



Acidizing was young in 1932 and pressure played little part in the operations. Modern pumps are designed for high pressure.

This steam engine was last word in rig power a few years ago.



An 825-hp mud pump was undreamed of in the early thirties.

tions with the smaller tender-served platform gaining increasing popularity.

Finally, the future should bring an increasingly higher type personnel to oil-field work. No longer is the term "roughneck" valid. Today's tools and machinery require skilled, sober, and conscientious operators, and leave little room for the itinerant boomer. More and more the executive and supervisory positions, including drillers and tool pushers, will be filled by men with basic engineering type training.

Production Practices

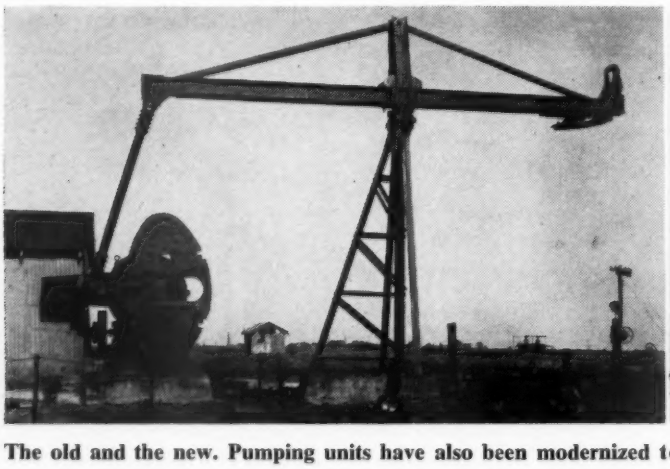
In 1929, the United States produced, for the first time in its history, over 1 billion bbl of crude oil. This feat, not surpassed volumewise until 1936, represented 67.8 per cent of the world's crude oil production for the year and has not been equalled percentage-wise since. Texas, California, and Oklahoma were, in the order listed, the largest producers, their fields having yielded nearly 845,000,000 bbl, 82.8 per cent of the United States total and 56.9 per cent of the world total.

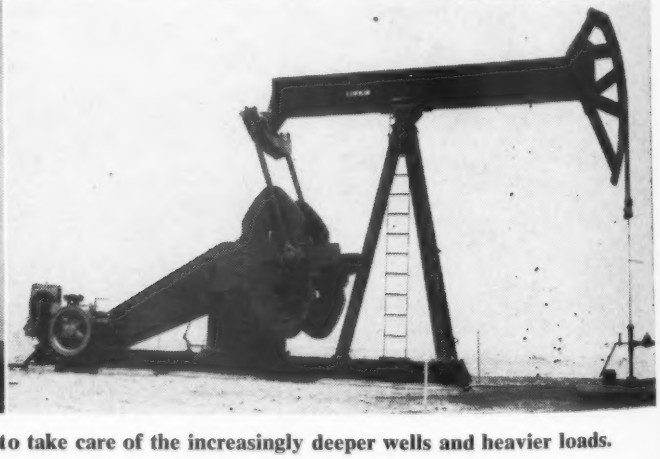
Completions generally were of the open hole type with casing set on top of the producing formation. In the harder producing horizons the oil bearing zones were customarily shot with explosive, either liquid or solidified nitroglycerin or its equivalent, the debris cleaned out, and the well placed on production. Completions in less consolidated zones required a somewhat different technique. There a slotted or perforated liner or a wire wrapped screen was used to exclude the soft sands from the well bores. Frequent cleanout jobs were often required in these liner type completions due to improper screen size and failure of screens. Undoubtedly the prevailing high flow rates also contributed to "sanding up" of the wells. Electric logs were available but were, in 1929, rudimentary, single curve affairs portraying only formation resistivity and valuable primarily for correlation work. Cementing equipment was light weight and low powered by today's standards, 250 sacks of common cement landed with 3000-lb pump pressure being a job that taxed available tools almost to the limit. Perforating as we accomplish it today was unknown. A few mechanical perforators or casing rippers were in use but were unwieldy and frequently damaged casing to an undesirable degree. Surface equipment for treating, producing, storing, and transporting oil was relatively crude and, though adequate for operating pressures of the time, far too light for today's service.

The pioneers of the late twenties and early thirties were successful in fulfilling the nation's demands for crude oil, however, and, through their ingenuity and planning, laid a firm foundation for the development of the industry as it now exists. Future operations will, undoubtedly, make obsolete today's equipment and methods just as surely as present tools and practices have replaced those of 25 years ago.

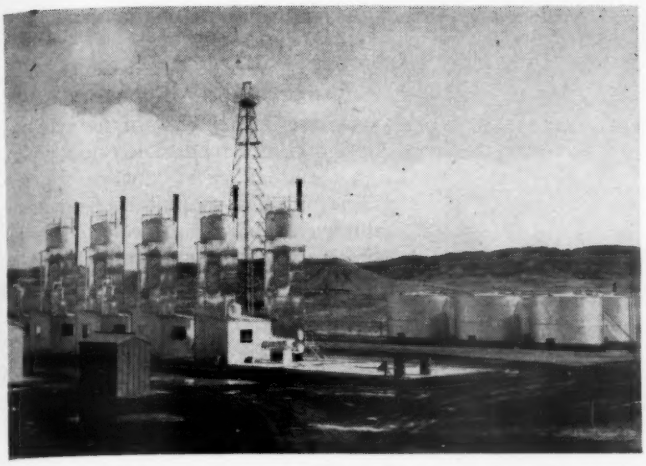
Well Equipment

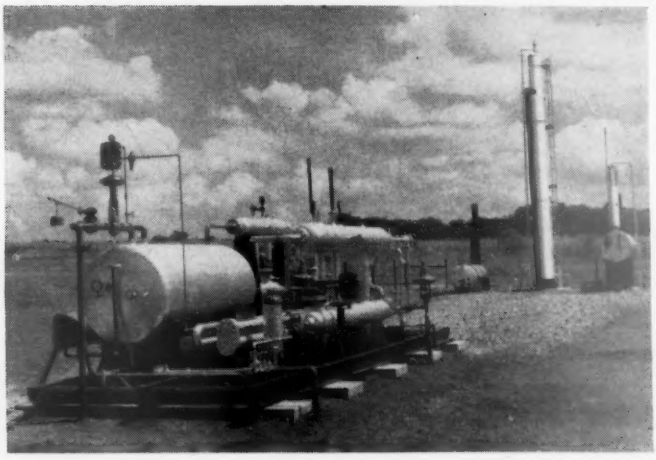
Oil well casing and cementing techniques probably serve as well as any item to demonstrate the growth and development over the past quarter century. While seamless pipe was offered in 1929, welded pipe in the old cable tool sizes, 6⅝-7⅝-8⅝, etc. was still popular. Cementing was similar to the operation today. Operators were encouraged to use 2 plugs and slurry weights were controlled. Operational difficulties with the 2 plugs caused unpopularity with the technique, especially when setting on top of the formation and good results were generally obtained with 1 plug, so this later method was more popular. The invention of gun-perforating and the advent





The old and the new. Pumping units have also been modernized to take care of the increasingly deeper wells and heavier loads.





Modern producing equipment is designed to lower operating costs and improve quality and volume of the produced fluid.

of the "set through and shoot" completion method in the early thirties made an uncontaminated cement bond at the sand face more desirable and forced the return to the two-plug method. Research and development of plugs with better operating characteristics and better design of surface plug containers also helped in improving the popularity of the method. Postwar developments in cementing have been widespread. Centralizers, scratchers, improved float equipment, additives to control weight and characteristics of slurry have all appeared. Cement squeeze operations began in 1933 and have carried forward to today a constant stream of improvements that have added substantially to the average success of the operation. One new technique, the diesel oil cement squeeze, appears to have particular merit when it is properly applied.

Squeeze tools—the hydraulically set retrievable packer, packers with positive slips, drillable squeeze packers—all have become increasingly efficient in very recent years.

The whole of the development in cementing has had but one aim—to place the most suitable possible bond in the correct places with the greatest ease and least expense. The vast strides toward accomplishing this have placed increasing demands on the perforating industry.

Gun-perforating, the forerunner of today's tools, was first generally used in the very early thirties. Early guns and bullets were not, of course, nearly as efficient as modern ones but they did open up new possibilities for completion for the operator and received early and widespread acceptance. Though the development of the bullet gun was somewhat arrested by the war, improvement since has continued. Of particular importance are the advances that permit operation of the tool under the higher pressures and temperatures found in today's deep wells.

Adaptation of the war-developed bazooka shell to casing perforating is of particular importance. The jet, or shaped charge, is now in widespread use where greater penetration is desired or where extra power to penetrate concentric casing strings with hard cement sheathes is required.

New jet perforating techniques immediately probable have to do with greatly improved equipment for use in the permanent well completion method. In addition, the introduction in the near future of improved shaped charges which will produce larger holes and give greater penetration is expected. The maximum efficiency of this type perforation is scarcely approached in today's tools.

Future developments will also include improved jet perforating equipment for use in smaller pipe diameters associated with the slim hole drilling technique as well as continued improvement in hoists, liners, and service equipment.

Modern electrical logs represent an amazing chain of development from the single resistivity curve of 1929. Though acceptance of the so-called "electrical core" was far from being immediate and universal, improvements came rapidly. By 1932 the potential curve was in use and from these two basic measurements stem an almost unparalleled development, which is expected to be projected into the future. Continued improvement in induction tools, including longer coils to improve their performance in hard rock country, is expected. Other focused devices for use in salty muds and for investigation of thin beds will be improved. It is probable that a larger selection of combinations of various special logs to be run on one trip in the well will be available in the future.

Radioactivity logging has progressed rapidly. Improvements in the application of the neutron log to determination of porosity are even today being developed. Along the same line we may expect a bore hole application of the scintillation counter in the near future.

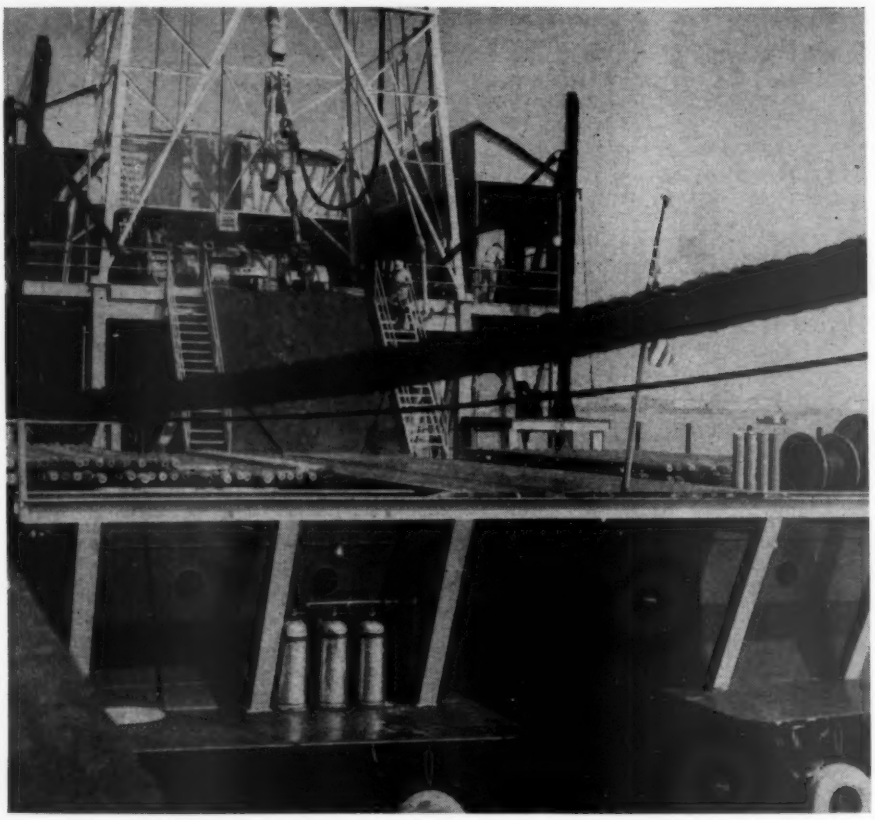
Completions

Even in 1929 the earlier practice of drilling in with the well flowing was generally considered a poor operation. Little thought was given the adverse effects of water on producing formations, however, and any mud with weight adequate to control formation pressure was considered suitable for a completion fluid. Earlier, work had been done with acid for improving delivery from carbonate rocks, in fact, well treatments had been made before the turn of the century. It was in 1929, though, that hydrochloric acid was successfully used to improve performance on an injection well and 1931 when an inhibited acid was put into an oil well. Progress in the chemical treatments of wells since that date has been remarkable. Surface tension agents, fluorides, surfactants, demulsifying agents, and corrosion inhibitors all appeared early. Improvement in pumps and connections permitting acid injection into tight formations under high pressures were developed and acidizing rapidly became the important completion tool it is today.

Future improvements in the techniques of simple acid injections are apt to be limited to the development of better inhibitors and retarded acids that will achieve deeper penetration into the formation before spending themselves.

These are relatively unimportant when considered in conjunction with the promises of fracturing with acid, a development with a great deal of future possibility.

The various fracturing processes developed in the late forties might be considered an outgrowth of both cementing and acidizing in that the high



Water operations loom large in the scheme for future drilling programs.

pressure equipment developed for these services most certainly is required. This process is of too recent a development and has been too widely documented to need further discussion. Without doubt it has added tremendously to the recoverable reserves of the nation. Probably in conjunction with secondary recovery processes it will continue to grow in importance in the coming years.

It is probable that fracturing will exert a considerable influence on well spacing in the future. Even today in certain areas 80-acre spacing is considered normal where a very few years ago even 40-acre spacing was questioned as being an effective drainage pattern.

Completion fluids, as well as drilling fluids, continue to receive merited attention. The true importance of reduction or prevention of water blocks in producing sands is daily emphasized in operations. Much progress in reducing existing blocks has been made in the field of chemical treatment. Attention to factors causing these blocks and their elimination during drilling should receive additional work in the future.

Surface Equipment

Gone are the days of the open earthen pits for lease storage of crude oil. Modern tankage conserves gravity, reduces fire hazards, and eliminates seepage loss. Treating of emulsions is no longer the haphazard and wasteful process it once was either, with modern chemicals and treating equipment operating together to reduce costs and preserve the quality of the oil.

Perhaps the greatest advancements in surface production equipment are seen in that designed to handle today's high pressure gas condensate production. Two rough groupings may be made of this equipment, one where a desiccant is used to dehydrate produced fluid before hydrate formation, the other where water is removed by lowering well fluid temperature. Both systems are marvels of modern technique and, indeed, have little counterpart in equipment that was in use 25 years ago.

The art of artificial lift has progressed as all other industry phases. In the field of rod pumping, perhaps the long stroke hydraulic unit will assist in solving the coming problems of artificially lifting deeper wells. Gas lift has made remarkable strides in recent years in improved lift efficiency and stamina of equipment. Technological advances in design of installation and selection of lift technique are also seen. Particularly worthy of note is the development of the equipment that makes possible the replacement of flow valves by wire lines.

Hydraulic subsurface units of greatly improved design are now available for general use. It must be noted that these, too, are potentially an answer to the eminent problem of economically producing deep wells.

Secondary Recovery

Almost 20 per cent of today's production comes from fields under pressure maintenance or repressuring programs and these techniques have added millions of barrels of oil to this nation's recoverable reserves. History of this method goes back to the late eighteen hundreds when both gas and water were injected in fields of New York and Pennsylvania. The middle thirties, however, saw the real beginning of the era of intensive application of injection practices. In 1932, fields being operated in this manner produced about 45,000,000 bbl of oil. Twenty years later, this type production accounted for 390,000,000 bbl of oil, an increase of nearly 900 per cent. The present outlook is for continued expansion in this field. Extensive research being conducted by both industry and government is aimed at increasing the yield from depleted and semi-depleted fields. Much promise is seen in tests of various detergents and other chemical additives for more thoroughly cleansing the producing formation. Tests of gas injection under extremely high pressures has been encouraging.

Very recently experiments utilizing high temperatures — actually burning a part of the residual crude in the formation—have been conducted with good results. In short, the whole field of secondary recovery is one presently receiving a great deal of attention. It is highly probable that improvements in methods and applications will lead to the ultimate recovery of a high percentage of what is now classed as unproducible crude.

Conclusion

It is, indeed, presumptuous to attempt a review of 25 progressive years of drilling and producing activity in a few pages. Obviously, the subject can only be superficially examined under these conditions. This brief summary is sufficient, however, to show the tremendous forward strides that this vital industry has achieved and to predict that its continued growth is virtually assured. With any kind of reasonably healthy economic conditions and under the impetus of free enterprise and competition, we shall continue to move forward. Our bits will drill more deeply when the need to do so is economically justified, our equipment will continue to improve, more economical means of producing and handling our oil will evolve, and an increasingly small percentage of our discoveries will be classed as unrecoverable and left behind. ★ ★ ★

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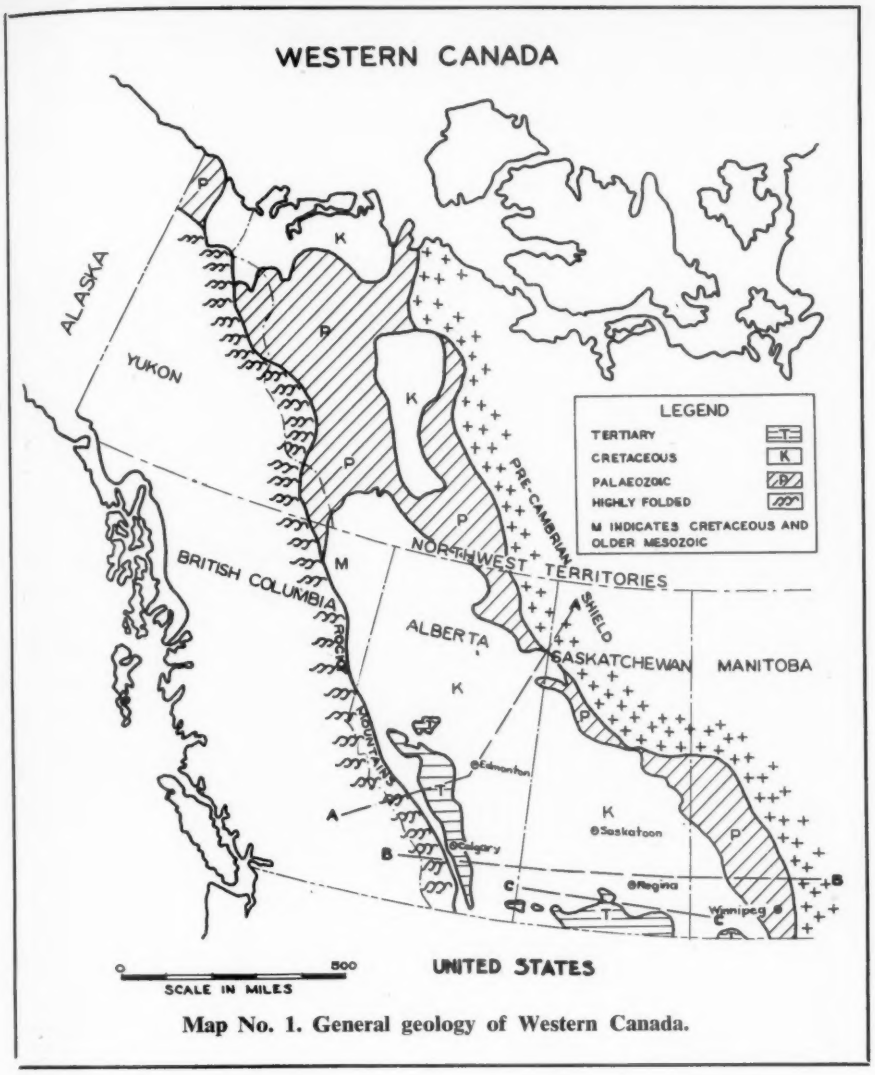


Map No. 1. General geology of Western Canada.

Petroleum Geology of Western Canada

F. H. EDMUNDS

Western Canada is comprised of three main physiographic and structural elements. These are the Mountain and Plateau areas extending from the Rocky Mountain front west to the Pacific Coast and north through the Yukon to the Arctic, the Central Plains area of sedimentary rocks, and the area of the Precambrian shield. The foothill belt, which borders the eastern front of the Mountain belt, and the Central Plains are the areas in which the oil and gas discoveries and developments of Western Canada have been made and, therefore, are the subject of this article. Explorations have been made in parts of the coastal area of British Columbia and also in some of the Plateau and valley areas of that province where there are considered to be oil and gas possibilities, however, no discoveries have been made up to the present.

The sedimentary area is a tract extending about 1600 miles from the International Boundary to the Arctic Ocean with a width of 800 miles in the south and narrowing to the north. It has an area of about 750,000 sq miles and occupies the southwest part of Manitoba, approximately the southern two-thirds of Saskatchewan, all but the northeast corner of Alberta, northeastern British Columbia, the east part of the Yukon and the west part of the Northwest Territories. The most accessible and, therefore, the best known part of the belt lies in the prairie areas of Manitoba, Saskatchwan, and Alberta, and is contiguous with the states of North Dakota and Montana.

The geological features of the southern plains of Western Canada were first examined by Dawson in 1873 and 1874, and by McConnell in 1883 to 1885. These members of the Canadian Geological Survey recognized the general similarity of the conditions to those described in 1862 by Meek and Hayden for the country to the south. Following the explorations of Dawson and McConnell more detailed work, stratigraphic and structural, was done mostly by members of the Geological Survey.

After the discovery of the Turner Valley field, southwest of Calgary in 1914, however, more oil company geologists made notable contributions. Turner Valley is in the foothills, consequently most attention was paid to that belt, however, slow but steady work was progressing in the plains area where a few discoveries were made. The first spectacular one was in 1947 when Leduc was discovered. Leduc was the spark that lit the prairie fire of exploration activity and resulted in the accumulation of much more knowledge about the geological conditions. Some of the knowledge is still in the oil company files but much has been published. The bibliography given at

The Author

F. H. Edmunds is professor of Geology at the University of Saskatchewan, Sasktoon, Canada. He received his BS degree in petroleum technology and his MS in geology from Liverpool University. He came to Saskatchewan as assistant professor of soils. After joining the Geology Department he carried out various investigations and surveys for the Department of Natural Resources and recently has done consulting work relating to oil and gas exploration and development. In 1952 he was appointed a member of the Saskatchewan Oil and Gas Conservation Board.

EXCLUSIVE

TABLE 1. Probability and profitability factors.

		Probabilities of Accumulation	
		Favorable	Doubtful
TRAP	Closure	Provable closure with relief in excess of thickness of oil objective; proof of critical dip on flank of anticline opposed to regional tilt; test is located with reference to gas-oil-water levels. Proof that closure is adequate to have retained oil; evidence of a seal to vertical migration. Proof that fault "Trap" is a seal—not a thorofare for up-dip migration. Beware the "bootleg" seismic map, the surface "high" in evaporite terrane, the subsurface prospect contoured on "estimated" datums!	Closure can only be inferred from interruption in Regional dip, or from multiple shows in a high well, or from inadequate seismic control; structural position is uncertain with reference to nearby levels of gas oil and water; reservoir may be depleted by old production, flushed by natural water flooding or drained by early geologic movements; reservoir beds are transitional upward in permeability; fault displacement could juxtapose porous zones allowing through migration of oil and gas; map datum and oil objective are separated by an unconformity.
	Wedge-edge	Wedge-edge accurately delineated; test located in a favorable structural position with respect to gas, oil and water levels and pay thickness. Porosity of a wedging reservoir may have been improved by truncation and subaerial leaching or by sorting of an onlapping objective. Effective seal to vertical and up-dip migration.	Direction and rate of convergence uncertain; structural position of test with relation to wedge-edge, pay thickness or fluid content is doubtful. Porosity may be affected adversely by convergence factors, cementation or diagenesis; transitional vertical permeability may indicate unfavorable connate water saturation and poorly sealed reservoir rocks.
OBJECTIVE		Proof of a thick porous reservoir objective which is consistently developed, and the prospect lies within the producing trend of this specific reservoir.	Variations in porosity and pay thickness approach the minimum economic limits of development; pay may wedge-out across structurally high prospect.
		Profitability Considerations	
		Income	Expense
ECONOMICS		Crude and gas price, oil gravity, gas-oil-water saturation, per acre recovery, well spacing, productive reservoir area, allowables, pay-out, depletion.	Acreage bonuses, commissions, royalties, oil payments; exploration expense; drilling, testing, equipping, and producing costs; taxation.

major exploratory programs to evaluate sub-provinces within the known favorable regions eventually followed by increasingly competitive lease acquisition and more economical operation of the independents. We currently observe varying stages of this trend in the remarkable 20 per cent wildcatting success in intensely explored areas of the Mid-Continent conducted largely by independents in contrast to the less advanced stages of primarily major company exploration of, for example, the Williston Basin.

As subsurface control accumulates and farmout acreage becomes more available the independents, hedging greater dry-hole risks by contributions and sale of interests, gradually dominate the drilling and discovery picture. Obviously, the individual fortunes possible from small leases will always attract risk-capital when such reserves have long since failed to meet major company crude requirements.

Importance of Tax-Money

These considerations involve one of the remarkable developments in the search for petroleum—the increasing importance of tax-money investments from outside the industry and the need for greater prudence as this money is invested by independent promoters. Those of us who deal principally with the independents are sometimes amazed by the kind of prospect and divisions of interest undertaken in these tax money-operator relationships. Undoubtedly the industry benefits by the introduction of such risk capital because it permits more wildcat wells to be drilled and tests proportionately greater areas of competitively owned acreage and unanticipated petroleum reserves. If so, it would seem good business to provide these investors with the greatest reasonable chance to profit; yet, it often appears that tax-money is promoted into ventures that would not conceivably attract the operator's personal investment.

Oil Is How You Find It*

This is the situation in which that salt-caked adage "oil is where you find it" and its corollary "you can't tell 'til you drill it" (with the intent of implying that oil finding is pure luck) becomes an offense to human intelligence. If there is any one crucial observation derived from the last 25 years of drilling that should govern our future exploration, it is fact that the best record of discovery is made through utilization of combined geophysical and geological techniques. In fact, where subsurface control is reasonably abundant and reflection seismic mapping is combined, the odds of discovery will be appreciably better than the present excellent 20 per cent record (by all methods) of many currently active oil regions. This is true because most of the prerequisites for petroleum can be ascertained in advance of drilling; so many, in fact, that approximations as to the quality of reservoir objective, drilling and completion cost, and other economic factors permit some choice as to the class of prospect in terms of both chance of success and degree of profit (Table 1).

Thus, depending upon the capital outlay and the odds of success, it seems only reasonable to provide the investor with a share in enough ventures to expect a profit, even if it means confining operations to shallower less prolific objectives or spreading the capital further by additional sales of partial interest.

In other words, by whatever means the independents, who seem destined to play an increasingly important part in the exploitation of the remaining economically accessible reserves, are financed, they will succeed in the long run in proportion to their ability to screen prospects and play the long term odds against the success of any individual venture. Judging from how oil is being found, the next quarter century may witness the demise of the doodle bugger, the not-so-educated hunch and the dry-hole profits because it looks as though the competition will get tougher. * * *

*Wheeler, Robert R., "Oil Is How You Find It," *World Oil*, October, November, 1951.

"Greatest Power Plant on Earth"

Dr. Charles F. Kettering, internationally-famed inventor and scientist, in a talk to the National Petroleum Association said that the American people can depend on the cooperation of the oil and automotive industries "for the best rubber-tired transportation anywhere at the lowest possible cost."

Dr. Kettering told the oil men that normal business requires planning of at least 5 to 10 years ahead, while research and development requires at least 15 to 20 years.

The director and research consultant for General Motors Corporation said the nation's 55,000,000 automobiles represent the greatest power plant in the world. Tremendous strides have been made in fuel and lubricants since the war. "You fellows in the oil business have done a wonderful job," he said.

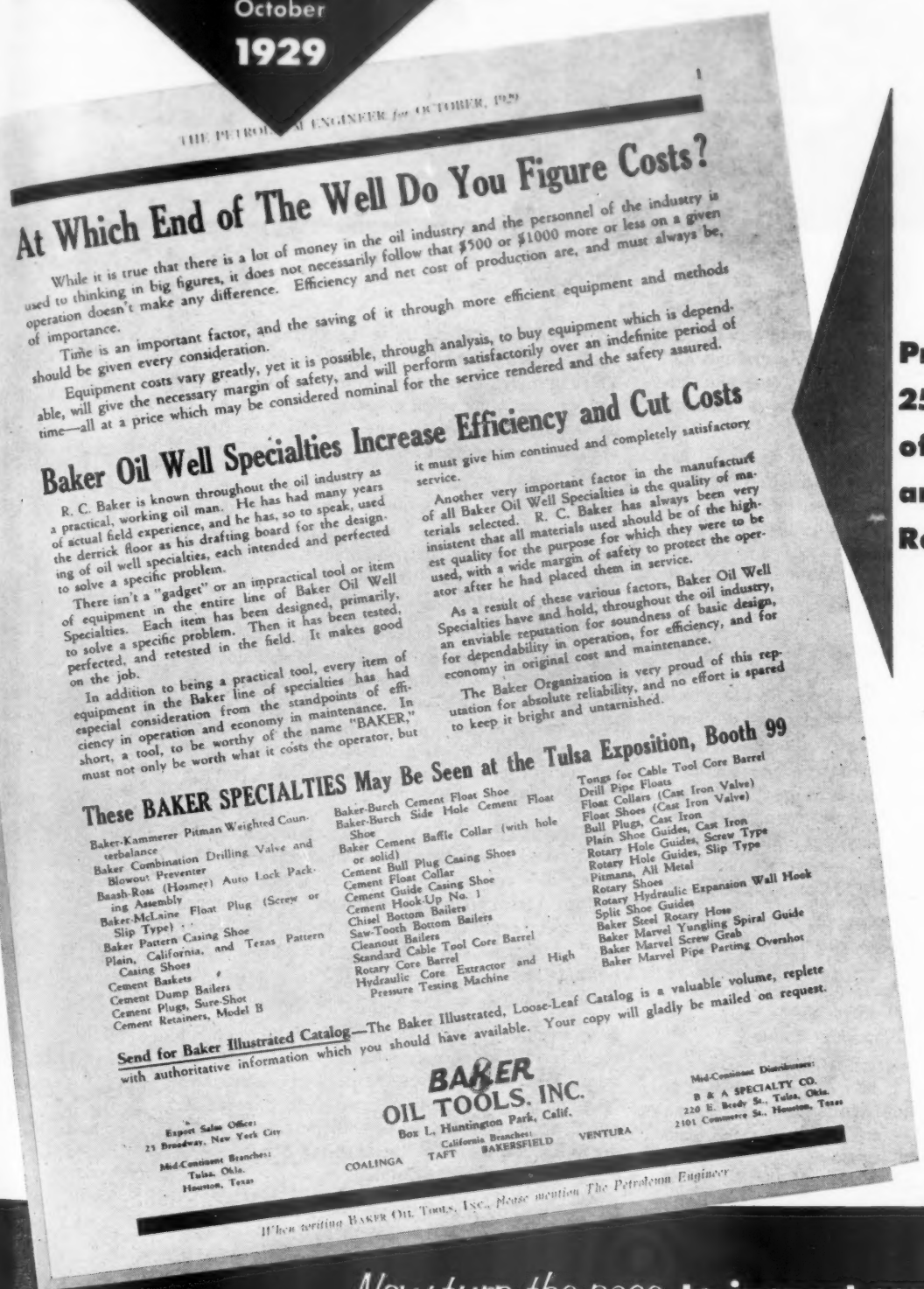
Referring to the automotive industry, Dr. Kettering said their designers were "trying to raise the ratios of engines as fast as you fellows can raise the octanes.

"I've been asked at times why we are trying to do this; whether it really means anything," he said. "The answer is very simple—with a 12 to one ratio, you can get twice as much mileage from the same amount of gasoline. That's getting the most out of our resources."

XUM

A lot can be done in 25 YEARS if you work at it!

The Baker Advertisement in the FIRST Issue of THE PETROLEUM ENGINEER October 1929



THE PETROLEUM ENGINEER for OCTOBER, 1929

At Which End of The Well Do You Figure Costs?

While it is true that there is a lot of money in the oil industry and the personnel of the industry is used to thinking in big figures, it does not necessarily follow that $500 or $1000 more or less on a given operation doesn't make any difference. Efficiency and net cost of production are, and must always be, of importance.

Time is an important factor, and the saving of it through more efficient equipment and methods should be given every consideration.

Equipment costs vary greatly, yet it is possible, through analysis, to buy equipment which is dependable, will give the necessary margin of safety, and will perform satisfactorily over an indefinite period of time—all at a price which may be considered nominal for the service rendered and the safety assured.

Baker Oil Well Specialties Increase Efficiency and Cut Costs

R. C. Baker is known throughout the oil industry as a practical, working oil man. He has had many years of actual field experience, and he has, so to speak, used the derrick floor as his drafting board for the designing of oil well specialties, each intended and perfected to solve a specific problem.

There isn't a "gadget" or an impractical tool or item of equipment in the entire line of Baker Oil Well Specialties. Each item has been designed, primarily, to solve a specific problem. Then it has been tested, perfected, and retested in the field. It makes good on the job.

In addition to being a practical tool, every item of equipment in the Baker line of specialties has had especial consideration from the standpoints of efficiency in operation and economy in maintenance. In short, a tool, to be worthy of the name "BAKER," must not only be worth what it costs the operator, but it must give him continued and completely satisfactory service.

Another very important factor in the manufacture of all Baker Oil Well Specialties is the quality of materials selected. R. C. Baker has always been very insistent that all materials used should be of the highest quality for the purpose for which they were to be used, with a wide margin of safety to protect the operator after he had placed them in service.

As a result of these various factors, Baker Oil Well Specialties have and hold, throughout the oil industry, an enviable reputation for soundness of basic design, for dependability in operation, for efficiency, and for economy in original cost and maintenance.

The Baker Organization is very proud of this reputation for absolute reliability, and no effort is spared to keep it bright and untarnished.

These BAKER SPECIALTIES May Be Seen at the Tulsa Exposition, Booth 99

Baker-Kammerer Pitman Weighted Counterbalance
Baker Combination Drilling Valve and Blowout Preventer
Baash-Ross (Hosmer) Auto Lock Packing Assembly
Baker-McLaine Float Plug (Screw or Slip Type)
Baker Pattern Casing Shoe
Plain, California, and Texas Pattern Casing Shoes
Cement Baskets
Cement Dump Bailers
Cement Plugs, Sure-Shot
Cement Retainers, Model B
Baker-Burch Cement Float Shoe
Baker-Burch Side Hole Cement Float Shoe
Baker Cement Baffle Collar (with hole or solid)
Cement Bull Plug Casing Shoes
Cement Float Collar
Cement Guide Casing Shoe
Cement Hook-Up No. 1
Chisel Bottom Bailers
Saw-Tooth Bottom Bailers
Cleanout Bailers
Standard Cable Tool Core Barrel
Rotary Core Barrel
Hydraulic Core Extractor and High Pressure Testing Machine
Tongs for Cable Tool Core Barrel
Drill Pipe Floats
Float Collars (Cast Iron Valve)
Float Shoes (Cast Iron Valve)
Bull Plugs, Cast Iron
Plain Shoe Guides, Cast Iron
Rotary Hole Guides, Screw Type
Rotary Hole Guides, Slip Type
Pitmans, All Metal
Rotary Shoes
Rotary Hydraulic Expansion Wall Hook
Split Shoe Guides
Baker Steel Rotary Hose
Baker Marvel Yungling Spiral Guide
Baker Marvel Screw Grab
Baker Marvel Pipe Parting Overshot

Send for Baker Illustrated Catalog—The Baker Illustrated, Loose-Leaf Catalog is a valuable volume, replete with authoritative information which you should have available. Your copy will gladly be mailed on request.

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Proved by 25 Years of Service and Successful Results

Now turn the page **to inspect some of the outstanding BAKER Products offered October, 1954**

BAKER *Tools for Today's Operations*

Here are a few of the most outstanding Baker Oil Tools for 1954. Complete details, illustrations and specifications are in your new 1954 Composite Catalog, starting on Page 435, where many other important Baker Products will be found.

▶ No other product has proved so successful for so many applications as the BAKER RETAINER PRODUCTION PACKER, which can be set on tubing, drill pipe, or on a wire line. Look on Page 496 of the 1954 Composite Catalog to learn how it is used for single-zone or dual-zone production; as a squeeze tool for acidizing or cementing; as a tubing anchor and as a bridge plug.

▶ For placing cement slurry, plastic, acid or other fluids, the BAKER RETRIEVABLE CEMENTER provides a safe, positive "Hold-Down Type" Packer which operates mechanically rather than by fluid pressure. Look on Page 495 of the 1954 Composite Catalog.

▶ BAKER CASING BRIDGE PLUGS can be set on tubing, drill pipe, or on a wire line to provide either a permanent or a temporary bridge plug which prevents either upward or downward movement of fluid or gas. Many other advantages are described starting on Page 474 of the 1954 Composite Catalog.

▶ No other product can equal the efficiency of the BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE for safely floating-in and landing casing strings of any length. Removes bridges, washes the formation, and imparts a "whirling" action to the slurry. See Page 438 of the 1954 Composite Catalog.

▶ With BAKER DIFFERENTIAL FILL-UP SHOES (or Collars) the casing is filled automatically as it is being run, to within 90% of the fluid level of the annulus. Eliminates the dangerous "Ram Effect" which may break down a potential lost-circulation zone. Permits the introduction of the action of a back-pressure valve at the discretion of the operator, for floating (if desired) and for cementing. Ask any Baker office for brochure containing complete details.

▶ BAKER FLEXIFLOW FILL-UP SHOES (or Collars) permit filling the casing automatically as it is being run, while maintaining a relatively constant level of dry (unfilled) casing until the casing has been landed. It is then possible to bring the Bakelite Ball Valve into play as a back-pressure valve for floating and/or cementing when desired. This latest Baker development is illustrated and described in a folder available upon request from any Baker office.

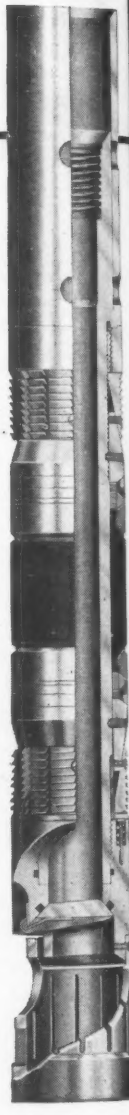
▶ For successfully placing cement or fluid at the place where it will be most effective, the BAKER CEMENT RETAINER has been "standard equipment" in International oil fields for many years. Read of its many uses starting on Page 474 of the 1954 Composite Catalog.

▶ The importance of having the I.D. of casing free from gun-shot burrs, hardened rotary mud and mill scale is evident from the rapidly increasing use of BAKER ROTO-VERT CASING SCRAPERS. Can be run easily and safely on drill pipe, tubing or a wire line, and leaves the "working surface" of casing clean and smooth for all future operations. Look on Page 517 of the 1954 Composite Catalog for details.

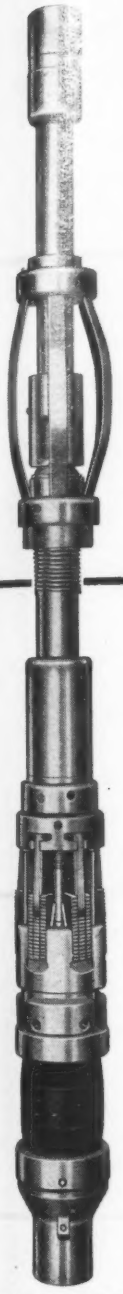
▶ When the time comes to center casing *positively*, and provide a uniform annular space for successful cementing, you need BAKER HINGE-LOK CASING CENTRALIZERS. Made in four ranges to exactly meet your casing programs, with many features not found in other centralizers. Interesting facts and illustrations start on Page 462 of the 1954 Composite (or Baker) Catalog.

▶ Controlled removal of the mud cake throughout the intervals to be cemented is positive and safe when BAKER WALL SCRATCHERS are used. The "scratching" action is minimized while running-in, but the spring-loaded wires with maximum reach dig in for best results on the upstroke. See Page 472 of the 1954 Composite Catalog.

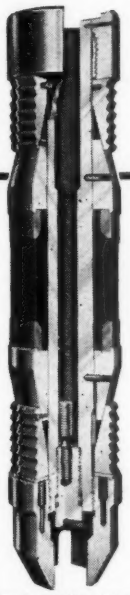
▶ Any drilling man will tell you how the BAKER DRILL PIPE FLOAT VALVE lengthens the life of wire lines and brake bands by relieving weight; how it prevents pulling "wet" strings; how it prevents or minimizes accidents in case the drilling string should part. See for yourself on Page 534 of the 1954 Composite Catalog.



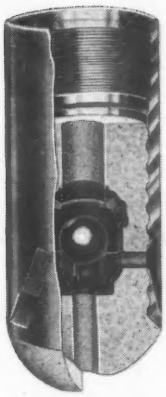
Baker Retainer Production Packer
Product No. 415-D



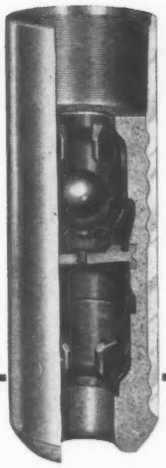
Baker Retrievable Cementer
Product No. 411-RT



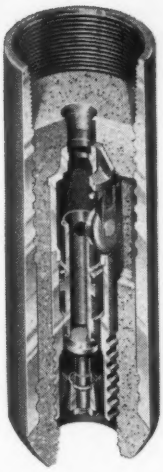
Baker Wire Line Bridge Plug
Product No. 400-N



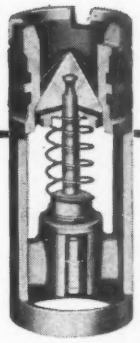
Baker Cement Wash-Down Whirler Float Shoe
Product No. 120



Baker FLEXIFLOW Fill-Up Shoe
Product No. 160

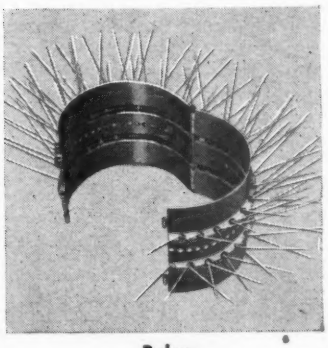


Baker Differential FILL-UP Shoe
Product No. 1081

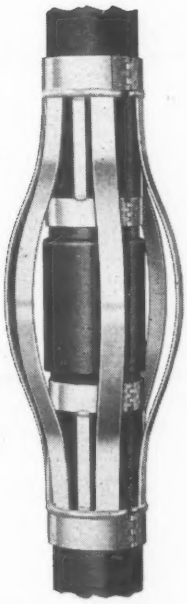


Baker Drill Pipe Float Valve
Product No. 4813

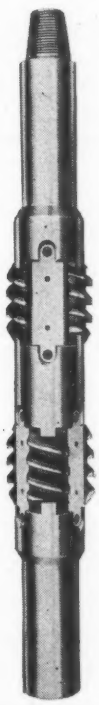
Baker Cement Retainer
Product No. 400



Baker Wall Scratcher
Product No. 900



Baker HINGE-LOK Casing Centralizer (H-25)
Product No. 9113



Baker ROTO-VERT Casing Scraper
Product No. 620-C

The Baker Section starts on Page 435 of your 1954 Composite Catalog; or if you prefer a separate BAKER Catalog, contact the office nearest you.

BAKER
OIL TOOLS, INC.
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Exploration, Drilling, Producing

Cuban-Canadian Pact

Cuban-Canadian Petroleum Company, Ltd., of Wilmington, Delaware, has signed an agreement with a group of Cuban petroleum executives for oil exploration on 4,992,700 acres of Cuban oil land. The area covered borders at one point on the new discovery well brought in last June in Camaguey Province. One part of the new Cuban-Canadian 30-year lease is within 400 yd of the Jatibonico wildcat now yielding approximately 150 bbl of oil daily. Drilling on new Cuban oil lands will begin within 90 days.

★ ★ ★

Alaskan Report Available

The USGS has completed and made available for inspection in Washington, D.C.; San Francisco, California, and Anchorage, Alaska, a geological report and map of the Malaspina district of Alaska and the adjoining petroliferous province. Numerous oil seeps, some of high gravity crude, have been reported in the area. Over 2,000,000 acres of Federal bases are granted or applied for and drilling operations are in progress in the Phillips-Kerr-McGee holdings in the northwestern part of the province.

★ ★ ★

Scholarships Are Awarded

Twenty-three sons and daughters of Cities Service Oil Company employees have been awarded scholarships by the Henry L. Doherty Educational Foundation, a Cities Service supported organization. The scholarships will be applied at a college selected by the student. Renewed scholarships were also granted to 33 additional students enabling them to continue their college studies.

★ ★ ★

Form Producing Subsidiary

The incorporation of Mobile Producing Company, wholly owned subsidiary of Socony-Vacuum Oil Company, Inc., has been announced. The new company will take over the operations formerly handled by the Pegasus division of Socony-Vacuum and conduct exploration and producing operations in the U. S. portion of the Williston Basin and in the northern Rocky Mountain area. Headquarters for Mobile Producing Company will be in Billings, Montana.

Ham Gossett Rules Set

Railroad Commission, after hearing in Austin, has established operating requirements for the Ham Gossett field of Kaufman County, Texas, prolific recent fault line discovery in the Mexia Talco trend. Chief among regulations are 20-acre spacing in Woodbine, and 1000 ft GOR limit. Allowable is to be based 75 per cent acreage and 25 per cent well.

★ ★ ★

AAODC California Meet Set

Annual convention of the nations Drilling Contractors is scheduled to be held in Los Angeles this year. Meeting dates are October 11 through 13, with an association sponsored ocean cruise to follow for those desiring. Meeting will be highlighted by the array of excellent papers planned and by the outstanding social program that has been announced. In this latter connection, the annual suppliers party is expected to be outstanding.

★ ★ ★

French Oil Strike

Esso Standard of France has reported the completion of the second well in the Les Landes area, a strip of barren sand and scrub pines along the shore of the Bay of Biscay. Potentialled and producing at a rate of 2400 bbl a day, the second well and the discovery well, which is flowing 3000 bbl per day are presently producing almost as much oil as the rest of the country combined. The operators have not made a public estimate of the potentialities of the area, feeling that it will be necessary to drill several more wells before the proper evaluation can be made.

★ ★ ★

Petroleum Meet Slated

The program for the 18th annual conference on petroleum production at Pennsylvania State University October 6-8, will include eleven papers on technical aspects of petroleum production by secondary recovery methods. Event attracts oil men from most of the oil producing states.

The Pennsylvania Grade Crude Oil Association, which maintains a production research laboratory in Bradford and has sponsored petroleum research for many years at Penn State, is cooperating in the conference.

Research Expanded

The Texas Company has implemented a substantial expansion of its research and technical activities by establishing an independent research and technical department and expanding its research facilities at the company's principal research laboratory at Beacon, New York.

Research and technical department will carry on a broad research program ranging from basic work in physics, chemistry, and engineering to the continuous development of new products and processes. In addition, it will also provide a variety of technical services to the sales and refining departments.

★ ★ ★

United Geophysical Sold

Union Oil Company of California has sold the assets of the United Geophysical Company, Inc., to a group of employees of the geophysical company headed by C. C. Lister, president, and E. A. Pielemeier, vice president.

Union Oil purchased the geophysical firm in 1950. Its sale is announced as being in line with the company's policy of encouraging and stimulating the growth of independent businesses.

CLIP YOUR OWN DRILLING MANUAL

When completed the Drilling Fundamentals series now being published in The Petroleum Engineer will be a valuable and comprehensive handbook of rotary drilling.

Don't miss clipping the installments in each issue. The pages fit standard loose-leaf notebooks.

Drilling Fundamentals will include 55 articles written by those who know drilling operations and can describe them. Turn to **Page B-126** now and clip this month's chapters on **Drilling Fundamentals.**

NOTHING TAKES
THE PLACE OF
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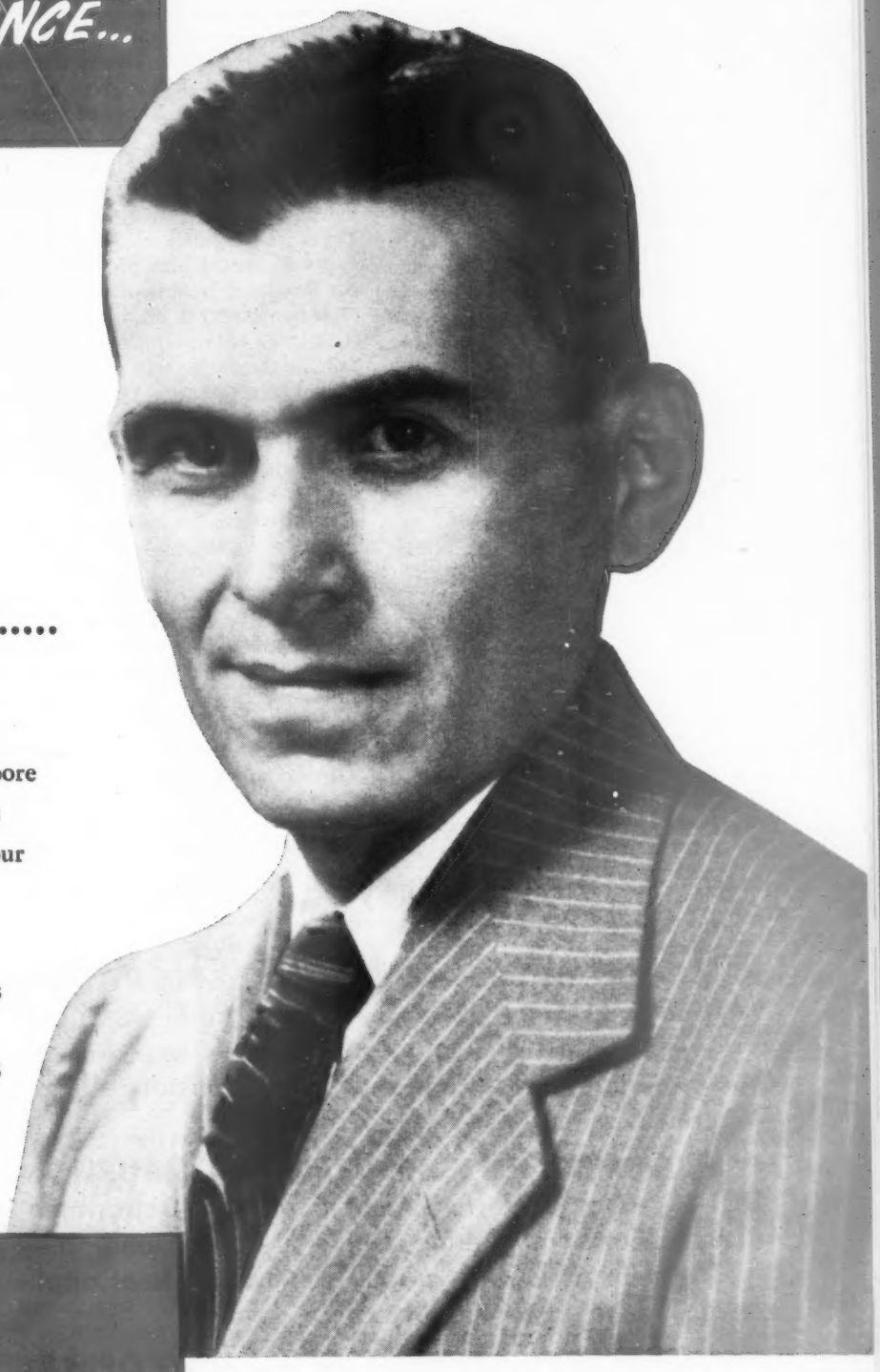
Help For You on Any Drilling Structure Problem . . .



Selecting just the right drilling structures for certain special conditions is very important. That's why Lee C. Moore retains an experienced team of engineers and sales consultants to help you with your drilling structure requirements.

J. E. Harrell is Lee C. Moore Northern Division Manager and is one of the sales consultants available to companies in the northwest and Canada. His over 25 years experience can be put to work for you when you need any type of drilling structure.

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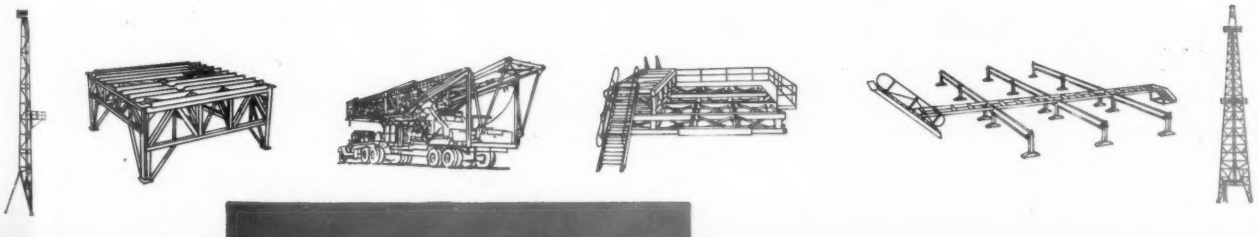


New Production Process

A new low-cost treatment to remove water blocks from oil-producing formations has been developed and tested by Stanolind Oil and Gas Company. Treatment utilizes a special class of surface-active agents dissolved in crude oil. These agents lower oil-water interfacial tensions to very low values. When used within critical concentration limits, an action is obtained which results in water movement, apparently in the form of an unstable emulsion of water in oil.

Agent used in the field trials was Atpet 931, manufactured by Atlas Powder Company. Equipment employed in these field tests consisted of conventional well-treating pump trucks and equipment.

Some spectacular results have been obtained with the new treatment. In one Gulf Coast well no production could be obtained following workover to repair casing leaks. Several cleanouts were made in an effort to regain production with no results. Well was then treated with 1000 gal of crude oil containing 1 per cent Atpet 931. Following treatment, well produced considerable water on gas lift and after a week began to flow. Twelve days after treatment the well was given a flowing test and produced 20 bbl of water and 67 bbl of oil.

Additional production increases have been observed covering periods of months following treatment. A West Texas well producing 12 bbl of oil per day was treated and produced 40 bbl per day after treatment. Four months after treatment the production rate had risen to 47 bbl of oil per day. A second well in the same area was producing 35 bbl of oil per day before treatment and immediately after treatment production was unchanged. At the end of a month, however, production had risen to 82 bbl of oil per day.

Field tests have been conducted on 90 wells at a total cost of about $39,000 to give a total increased oil production of about 1217 bbl daily. Thus, the average treatment cost has been about $430 per well, the average payout time has been about 20 days, and the cost per daily barrel of increased production has been about $32.

The new process will shortly be offered to the oil industry.

What's coming . . . in your November issue of "Drilling and Producing."

WILLISTON BASIN—EAST SIDE EXPLORATION AND GEOLOGY—Donald Towse, Consulting Geologist—Geological discussion of an extensive area where exploratory drilling may prove substantial shallow reserves.

DEVELOPMENT OF SUBSURFACE COMBUSTION DRIVE—Don V. Hester and D. E. Menzie, Department of Petroleum Engineering, University of Oklahoma—A complete review of various methods of heat application to increase recovery of crude oil.

METHODS IMPROVEMENT IN DRILLING OPERATIONS—Wilson J. Bentley, Consultant and Professor of Industrial Engineering, Oklahoma A&M. Second part in a series. Efficiency can be increased—study of crew activities show much lost motion.

PLUS an up-to-the-minute report of **API** convention activities.

READ these and many more articles important to your operations in the November **"DRILLING AND PRODUCING."**

SEG Schedules Dallas Meet

Oil exploration scientists attending the Dallas meeting of the Society of Exploration Geophysicists November 18 and 19 will be told about geophysical techniques now being used in the search for other minerals. A special session on uranium exploration has been organized to satisfy local enthusiasm and interest in the subject.

A session on management of exploration activities will also be held.

About 1000 geophysicists and geologists are expected to attend the meeting, which is sponsored by the Dallas, Fort Worth, Midland, Oklahoma City, Shreveport and Tulsa sections of SEG.

★ ★ ★

Trade Association Formed

Formation of the California Drilling Contractors Association to serve the interests of the contract oilwell drilling firms of the state has been announced. The trade organization is an outgrowth of the Contractors Statistical Committee which was formed in 1951 to do statistical research for drilling contractors.

First state-wide project will be a Driller Safety Education Training Program to start in early fall. A series of meetings will be scheduled for drillers at which they will receive intensive training in communicating safety methods to their crews. Meetings will be held in all major oil areas of the state.

★ ★ ★

Plan Spraberry Injection

At a recent hearing in Austin of the Texas Railroad Commission, Humble Oil and Refining Company requested permission to begin water injection in the Spraberry sand in the Spraberry trend field in Upton County, Texas. Present plans are for the experimental flood to begin with the injection of salt water into four wells on Humble's L. H. Shackelford "B" lease.

★ ★ ★

AIME Fall Meeting Set

The Petroleum Branch of the AIME has completed plans for the annual Fall conference to be held this year in San Antonio October 17-20. While registration will begin Sunday, full sessions are not scheduled to start until the following day. The program this year is complete coverage of oil field operations, including field case histories of selected fields of wide interest, well logging, a wide field of producing operations, reservoir studies, operating economics, drilling, and completion practices. A varied program of social entertainment is also planned.

What's New Tomorrow?

- *Deeper wells*
- *More efficient completions*
- *Greater reservoir recoveries*

All can be foreseen in the near future

SIM H. CREWS*

Portability and move efficiency rank high in modern rig requirements.

WHERE leads the path to the future? The task assigned the discoverer and producer of crude oil and natural gas seems clear. Historically the nation has seen an ever-increasing demand for his product with the coming of each new day. True, there have been and will probably continue to be minor fluctuations in this demand, but the trend has been an increasing one. In 1929, birth year of *The Petroleum Engineer*, the combined domestic and export demand for United States crude was for slightly more than 3,000,000 bbl a day. The depression reduced this to a low point in 1932 of 2,500,000 bbl. With few exceptions since this low was passed, each year has seen a steady improvement in the demand for petroleum and its products until in 1953, the staggering total of 2.9 billion bbl, over 8 million bbl a day, was used.

To say that natural gas has followed a parallel course would be, indeed, minimizing the gains reported for this valuable commodity. From a low of some 2 trillion cubic feet per year used in the depth of the depression, the consumption of natural gas has more than quadrupled with nearly 9 trillion cubic feet of natural gas being delivered to ultimate consumers in 1953.

Use of petroleum and natural gas is logically portrayed and gains emphasized through the device of expressing their contribution toward satisfaction of the total national energy requirements. In 1929, of the total U.S. energy needs, crude oil supplied 25 per cent and natural gas 9 per cent. That year coal was by far the greatest supplier of energy. Contrast this, then, with the figures for 1953, when crude oil supplied 41 and gas 23 per cent of a greatly increased total demand.

What has happened to our known reserves during this period of tremendously accelerating uses? Have they declined? Have they approached the vanishing point as many responsible men have predicted they would? The obvious answer to these is, of course, no. Our reserve picture today is stronger than at any time in our history. Here we are faced with a paradox seldom equaled. The more petroleum we use, the more we have available. Starting with some 12 billion known bbl in 1929, we have used to our hearts' content and have remaining now almost 3 times as much as we had then.

These few facts serve well to show the future course of oil and its partner, natural gas. The question of the path ahead can have but one answer and that an optimistic one. The future must bring forth in continued abundance the bounties of nature which are the fruits of the oil man's efforts, the product of men and materials, of tools and techniques. To realize how this will be brought about, let us review briefly the progress of the last 25 years in the industry.

Rotary Drilling

Average well depth in 1929 was 2897 ft. That year saw the completion of almost 27,000 holes, a level that was not to again be reached until 1937. It also witnessed a new depth record, 9280 ft, but one destined to be typically temporary in this vital industry, and which scarcely lasted out the year.

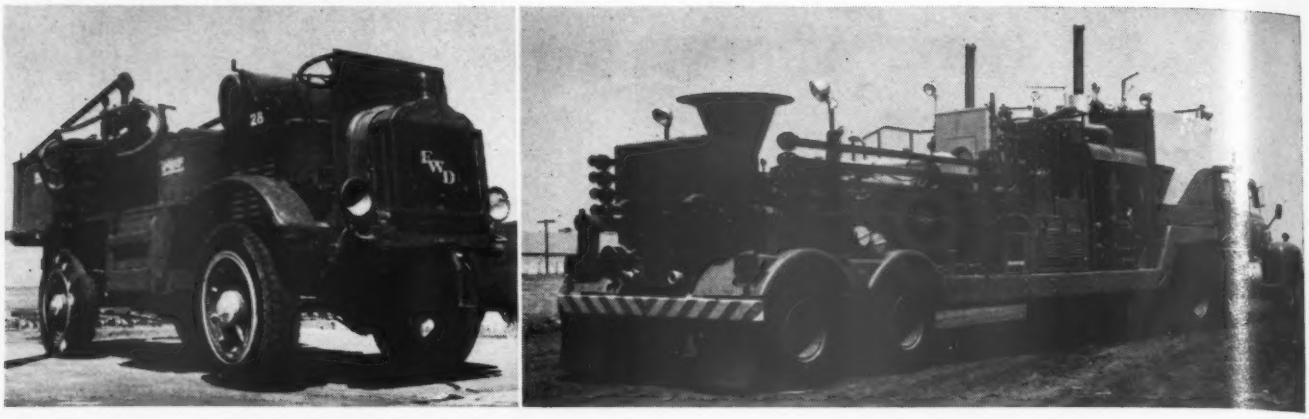
Rotary drilling rigs of the period were, indeed, a far cry from our modern machines, though much credit must be given the men who operated them, and nothing but admiration is due the results achieved with such rudimentary equipment.

It was still a period of "iron men and wooden derricks" for the most part. A few steel drilling and combination derricks were in use and their wide-spread acceptance was a foregone conclusion but the early day wooden structures were certainly not the novelty they are today.

Rig power was provided almost entirely by steam with a few electric rigs employed in development drilling. The first power (internal-combustion engine) rigs appeared in the early thirties. Relatively crude affairs, they were basically heavy duty pulling machines adapted to drilling service. Power transmission by chains and jaw clutches gave undesirable operating characteristics—power application, instead of being smooth and even as with steam, was very rough and operating personnel customarily referred to these early power rigs in most uncomplimentary terms. They did, however, have one thing in their favor over steam—mobility. They represent one of the earliest approaches to the modern unitized rig and did much to force development along this line. Today, of course, the power rig is the accepted drilling machine generally. The modern steam rig is an excellent tool offering wide flexibility in application of

*Editor, Exploration, Producing, and Drilling Edition.

EXCLUSIVE



Cement Truck No. 28, adequate for the wells of its time, would be hard pressed to compete with today's equipment.

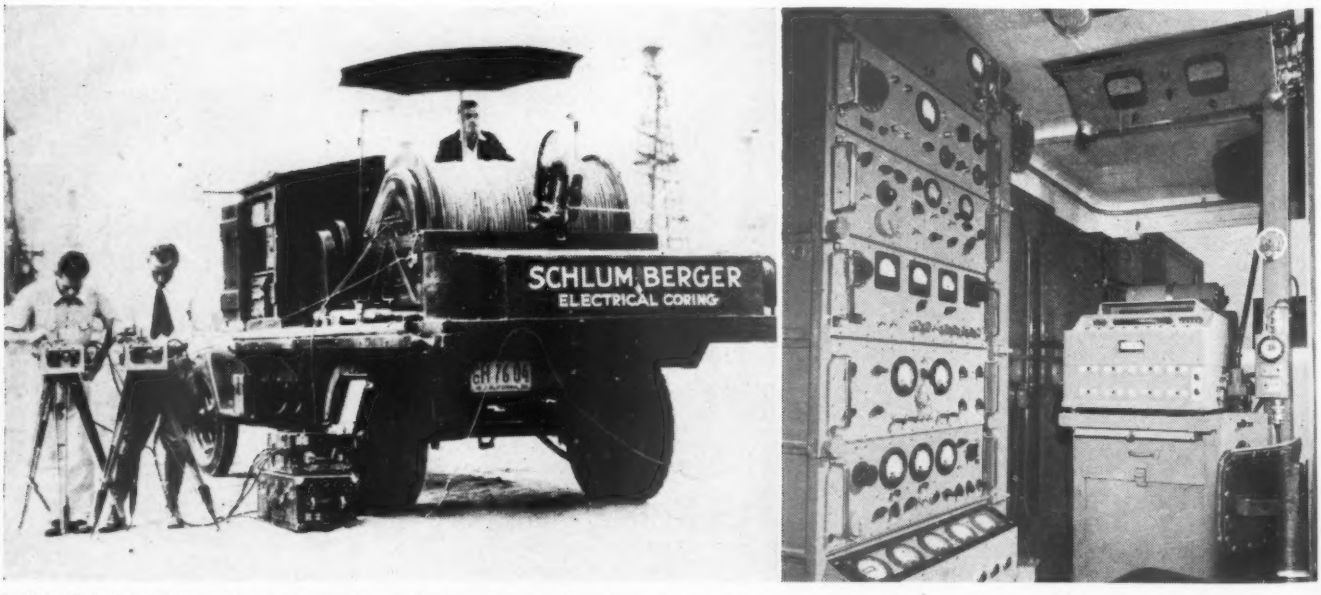
power, and generally is considered an ideal means of drilling. Even with the present-day improvement in its transportability, however, the steam rig generally requires a great deal of high priced fuel, and its water consumption is too great for it to effectively compete with the power rig in most areas.

Tremendous strides in the development of the power rig are evident. The compounding transmission, permitting the application of several engines to either the draw works, pumps, or rotary table, was an early development that contributed much to present-day equipment. Air clutches replacing the earlier jaw clutches added greatly to both smoothness and ease of operation.

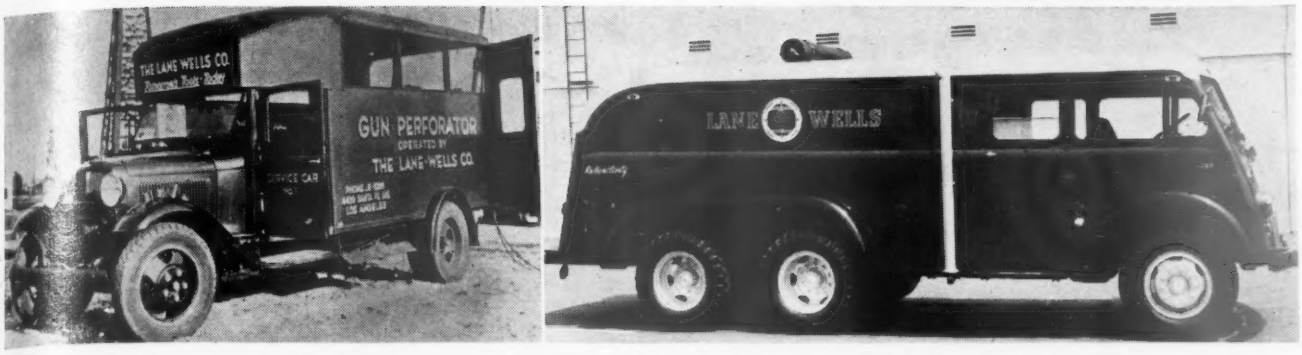
Not limited solely to power rigs were the hydromatic brake, a development that became common in the mid-thirties, and the water-cooled break drum. Prior to the advent of this equipment, round trips from any considerable depth were apt to be rather lengthy affairs characterized by frequent waiting periods while brakes were taken up and allowed to cool off.

The late forties and early fifties have brought to today's high state of development the modern methods of power transmission, the fluid coupling, the hydraulic torque converter, and the electro-magnetic coupling, and have seen their widespread acceptance by industry. Coincident with these developments has been the introduction of the high horsepower mud pump. At the time *The Petroleum Engineer* was founded and dedicated to the furtherance of engineering knowledge and its dissemination and application to practical oil field use, power mud pumps were relatively light and ineffective devices in the light of modern thinking. Drilling mud was primarily the result of making hole with clear water in those days, though a few drillers had begun to realize its importance in the drilling operation, and occasionally sought a nearby surface clay pit whose product could be used to improve the consistency of their drilling fluid. It was after World War II that the importance of fluid hydraulics in drilling received widespread recognition. At this time, the industry began to see big improvements in the capacity of power pumps and operations, utilizing the the latest developments in chemical drilling fluids and pumps in the 700-hp range, became commonplace.

Another development in recent years is the acceptance of long strings of heavy drill collars. Early day operators customarily drilled relatively large holes, 12 in. or more, and used large size drill pipe. One popular combination of the early thirties was 12¼-in. hole and 6⅝-in. drill pipe. With increasing depth, this heavy pipe placed an uneconomic load on available hoisting equipment, additionally retarding drilling rates. Operators then attempted to improve performance with smaller holes and lighter drill pipe with the result that 3½-in. and 4½-in. drill strings and 7⅞-in. to 9-in. holes became approximately standard. The original drill collar was actually a short combination coupling with a drill pipe box on one end and a bit pin box on the other. Reduction of drill pipe diameter and weight forced the redesign of the



This 1932 electric logging equipment was designed to produce two curves. Compare the early equipment with the instrumentation available in 1954.



Cased hole logging and gun perforating have come a long way in the time interval presented by these two pictures.

early drill collar into the heavy tube, usually 30 ft in length, common today. A better understanding of drilling requirements, the almost universal acceptance of the rock bit for most normal types of drilling, and the drilling of increasingly hard formations at greater depth all worked to force the operators into the practice of using several of these drill collars, sometimes as many as 20 or more.

The so-called "rock" bit has today almost surplanted the older "three-way" and fishtail bits even for drilling the soft shales of the Gulf Coast. This evolution is the product of a combination of improved rock bit design from a standpoint of tooth pattern, bearing capacity, and metallurgy, and the practice of carrying heavier bit loading while drilling. The change was also materially influenced by the increased understanding of fluid hydraulics and the use of modern-day chemical muds.

The coring operation has seen improvement comparable to that transpiring in other techniques also. From the early-day shop-made devices made of drill pipe and resembling superficially an elongated wash-over shoe to the modern wire line retrievable barrel is a long step. Available today for all important core recovery in extremely hard rock country are excellent diamond core heads and for softer coring we have both roller and blade type heads. Improved techniques and equipment have added greatly to the percentage recovery enjoyed by modern operators.

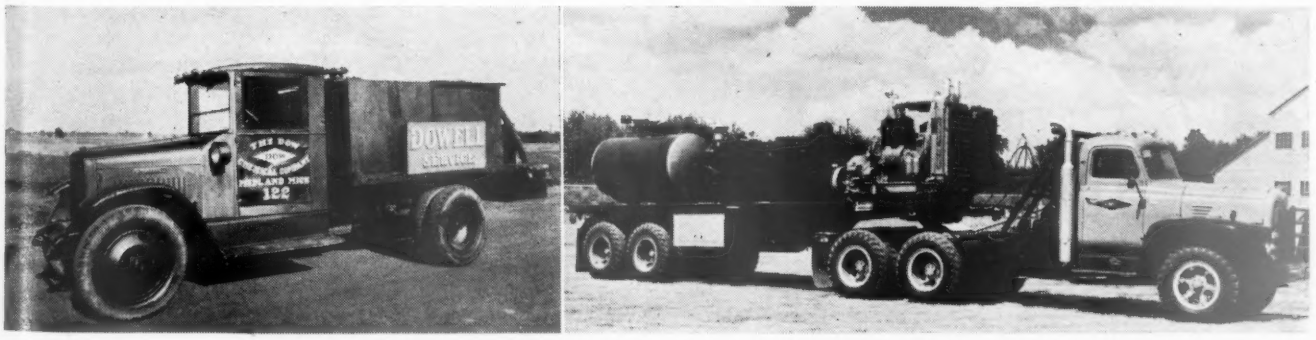
Last year (1953) the industry drilled nearly 50,000 wells at an average depth of slightly over 4000 ft. From the 1929 record of 9280 ft, the oil seeking bit has driven to a new level of 21,482 ft. These facts illustrate the progress the last 25 years have brought to oil-well drilling, and indicate well the trend for the future. It is quite obvious that, economic conditions remaining healthy, we shall drill increasingly deeper wells, more wells, and to a greater average depth, at least in the immediate future.

Many problems remain to be solved. Two of them, lost circulation and crooked holes, are of particular importance. As our wells go deeper the hydrostatic head due to the long column of drill mud reaches staggering proportions, particularly if heavy muds are used because of anticipated high formation pressures. Though considerable progress has been made in controlling loss and restoring circulation, much remains to be accomplished in this field. Crooked holes offer another challenge to the drilling man. In some sections of the country, the inclination and texture of formations make their penetration without excessive hole deviation most difficult. Improvement in this operation has been apparent also but here again much work remains to be done.

Penetration rates, particularly in areas of extremely hard rock, need and undoubtedly will receive, improvement. The tungsten carbide insert chert bit is an excellent example of the development of special tools to improve drilling efficiencies. Use of two cutter jets for better performance in softer drilling is an equally good illustration and of comparable importance. In the line of the newer tools, the sonic drill and the sub-surface turbine both offer promise for improving penetration rates, particularly in hard rock drilling and in crooked hole country.

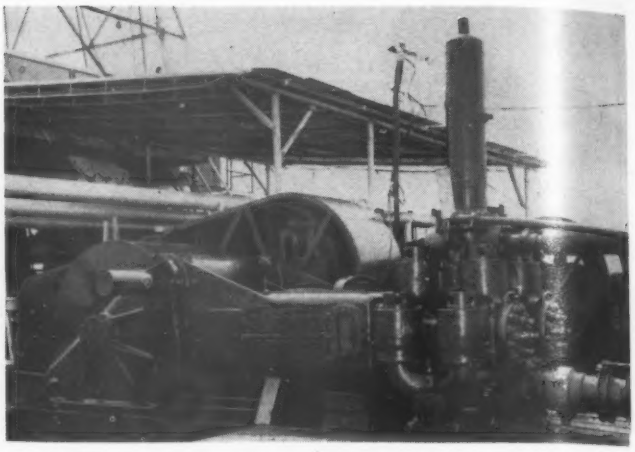
The drilling industry's record toward improving penetration rate in the last eight years is impressive. The AAODC estimates that, since 1946, drilling rates have increased almost 50 per cent. Through contractors' costs have practically doubled in recent years, the improved drilling rates achieved through application of fluid hydraulics, increased bit weight, better mud, and improved techniques, enable him to deliver hole to the operator today as cheap or cheaper than he did 15 years ago.

Rig mobility is of vital importance in the drilling field. Though not a major problem, with competition at its present level, every effort to reduce drilling cost is justified and a reduction in rig moving cost offers a partial means toward this end. It may be that the future will see rigs more nearly designed for specific jobs in selected areas. Exploration work may be handled by light, highly mobile equipment designed for drilling small holes to depths of 10,000, 12,000, or 15,000 ft, while development drilling is done by heavier machines. Barges and platforms will undoubtedly play a major role with the impending offshore opera-



Acidizing was young in 1932 and pressure played little part in the operations. Modern pumps are designed for high pressure.

This steam engine was last word in rig power a few years ago.



An 825-hp mud pump was undreamed of in the early thirties.

tions with the smaller tender-served platform gaining increasing popularity.

Finally, the future should bring an increasingly higher type personnel to oil-field work. No longer is the term "roughneck" valid. Today's tools and machinery require skilled, sober, and conscientious operators, and leave little room for the itinerant boomer. More and more the executive and supervisory positions, including drillers and tool pushers, will be filled by men with basic engineering type training.

Production Practices

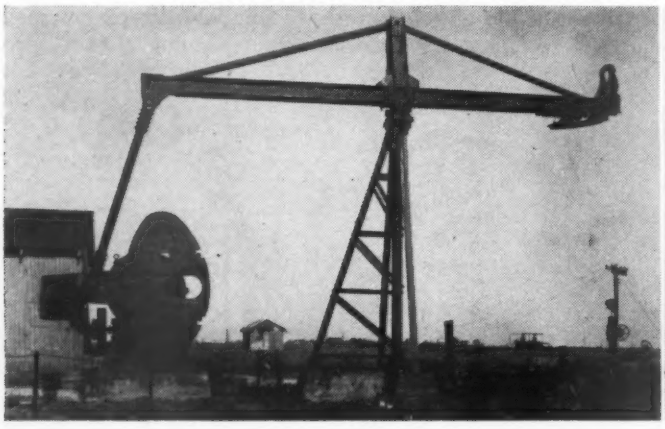
In 1929, the United States produced, for the first time in its history, over 1 billion bbl of crude oil. This feat, not surpassed volumewise until 1936, represented 67.8 per cent of the world's crude oil production for the year and has not been equalled percentage-wise since. Texas, California, and Oklahoma were, in the order listed, the largest producers, their fields having yielded nearly 845,000,000 bbl, 82.8 per cent of the United States total and 56.9 per cent of the world total.

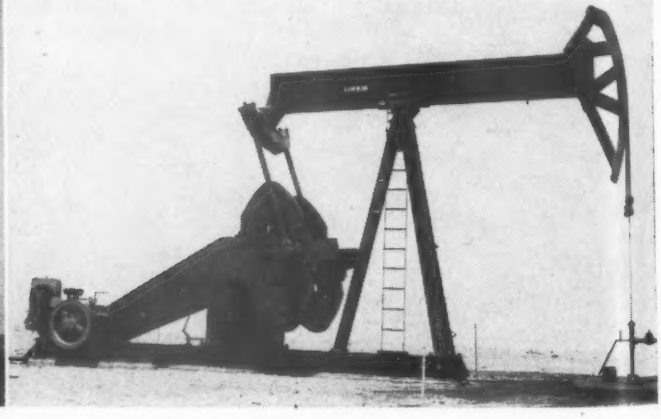
Completions generally were of the open hole type with casing set on top of the producing formation. In the harder producing horizons the oil bearing zones were customarily shot with explosive, either liquid or solidified nitroglycerin or its equivalent, the debris cleaned out, and the well placed on production. Completions in less consolidated zones required a somewhat different technique. There a slotted or perforated liner or a wire wrapped screen was used to exclude the soft sands from the well bores. Frequent cleanout jobs were often required in these liner type completions due to improper screen size and failure of screens. Undoubtedly the prevailing high flow rates also contributed to "sanding up" of the wells. Electric logs were available but were, in 1929, rudimentary, single curve affairs portraying only formation resistivity and valuable primarily for correlation work. Cementing equipment was light weight and low powered by today's standards, 250 sacks of common cement landed with 3000-lb pump pressure being a job that taxed available tools almost to the limit. Perforating as we accomplish it today was unknown. A few mechanical perforators or casing rippers were in use but were unwieldy and frequently damaged casing to an undesirable degree. Surface equipment for treating, producing, storing, and transporting oil was relatively crude and, though adequate for operating pressures of the time, far too light for today's service.

The pioneers of the late twenties and early thirties were successful in fulfilling the nation's demands for crude oil, however, and, through their ingenuity and planning, laid a firm foundation for the development of the industry as it now exists. Future operations will, undoubtedly, make obsolete today's equipment and methods just as surely as present tools and practices have replaced those of 25 years ago.

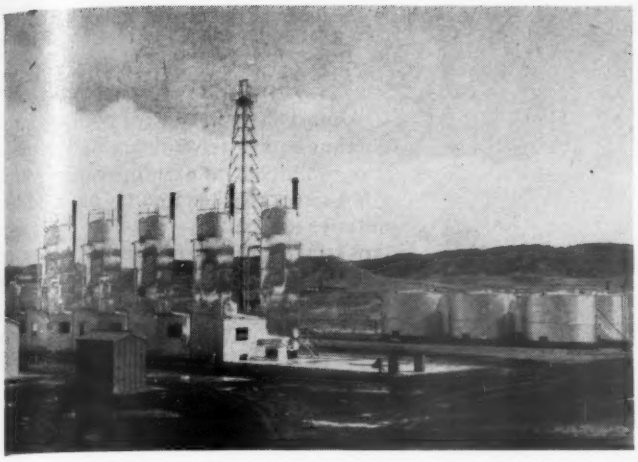
Well Equipment

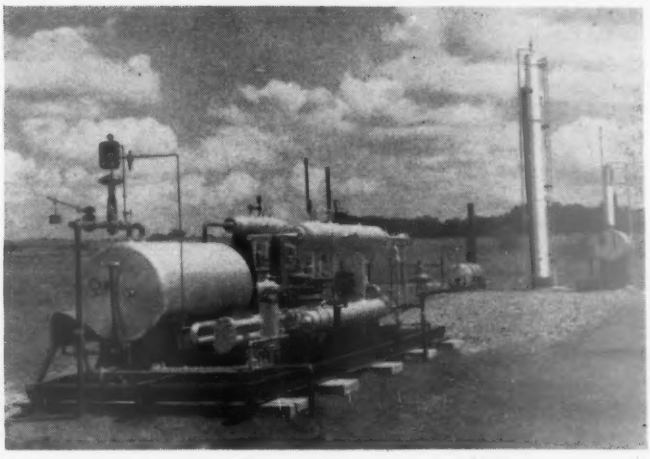
Oil well casing and cementing techniques probably serve as well as any item to demonstrate the growth and development over the past quarter century. While seamless pipe was offered in 1929, welded pipe in the old cable tool sizes, 6⅝-7⅝-8⅝, etc. was still popular. Cementing was similar to the operation today. Operators were encouraged to use 2 plugs and slurry weights were controlled. Operational difficulties with the 2 plugs caused unpopularity with the technique, especially when setting on top of the formation and good results were generally obtained with 1 plug, so this later method was more popular. The invention of gun-perforating and the advent





The old and the new. Pumping units have also been modernized to take care of the increasingly deeper wells and heavier loads.





Modern producing equipment is designed to lower operating costs and improve quality and volume of the produced fluid.

of the "set through and shoot" completion method in the early thirties made an uncontaminated cement bond at the sand face more desirable and forced the return to the two-plug method. Research and development of plugs with better operating characteristics and better design of surface plug containers also helped in improving the popularity of the method. Postwar developments in cementing have been widespread. Centralizers, scratchers, improved float equipment, additives to control weight and characteristics of slurry have all appeared. Cement squeeze operations began in 1933 and have carried forward to today a constant stream of improvements that have added substantially to the average success of the operation. One new technique, the diesel oil cement squeeze, appears to have particular merit when it is properly applied.

Squeeze tools—the hydraulically set retrievable packer, packers with positive slips, drillable squeeze packers—all have become increasingly efficient in very recent years.

The whole of the development in cementing has had but one aim—to place the most suitable possible bond in the correct places with the greatest ease and least expense. The vast strides toward accomplishing this have placed increasing demands on the perforating industry.

Gun-perforating, the forerunner of today's tools, was first generally used in the very early thirties. Early guns and bullets were not, of course, nearly as efficient as modern ones but they did open up new possibilities for completion for the operator and received early and widespread acceptance. Though the development of the bullet gun was somewhat arrested by the war, improvement since has continued. Of particular importance are the advances that permit operation of the tool under the higher pressures and temperatures found in today's deep wells.

Adaptation of the war-developed bazooka shell to casing perforating is of particular importance. The jet, or shaped charge, is now in widespread use where greater penetration is desired or where extra power to penetrate concentric casing strings with hard cement sheathes is required.

New jet perforating techniques immediately probable have to do with greatly improved equipment for use in the permanent well completion method. In addition, the introduction in the near future of improved shaped charges which will produce larger holes and give greater penetration is expected. The maximum efficiency of this type perforation is scarcely approached in today's tools.

Future developments will also include improved jet perforating equipment for use in smaller pipe diameters associated with the slim hole drilling technique as well as continued improvement in hoists, liners, and service equipment.

Modern electrical logs represent an amazing chain of development from the single resistivity curve of 1929. Though acceptance of the so-called "electrical core" was far from being immediate and universal, improvements came rapidly. By 1932 the potential curve was in use and from these two basic measurements stem an almost unparalleled development, which is expected to be projected into the future. Continued improvement in induction tools, including longer coils to improve their performance in hard rock country, is expected. Other focused devices for use in salty muds and for investigation of thin beds will be improved. It is probable that a larger selection of combinations of various special logs to be run on one trip in the well will be available in the future.

Radioactivity logging has progressed rapidly. Improvements in the application of the neutron log to determination of porosity are even today being developed. Along the same line we may expect a bore hole application of the scintillation counter in the near future.

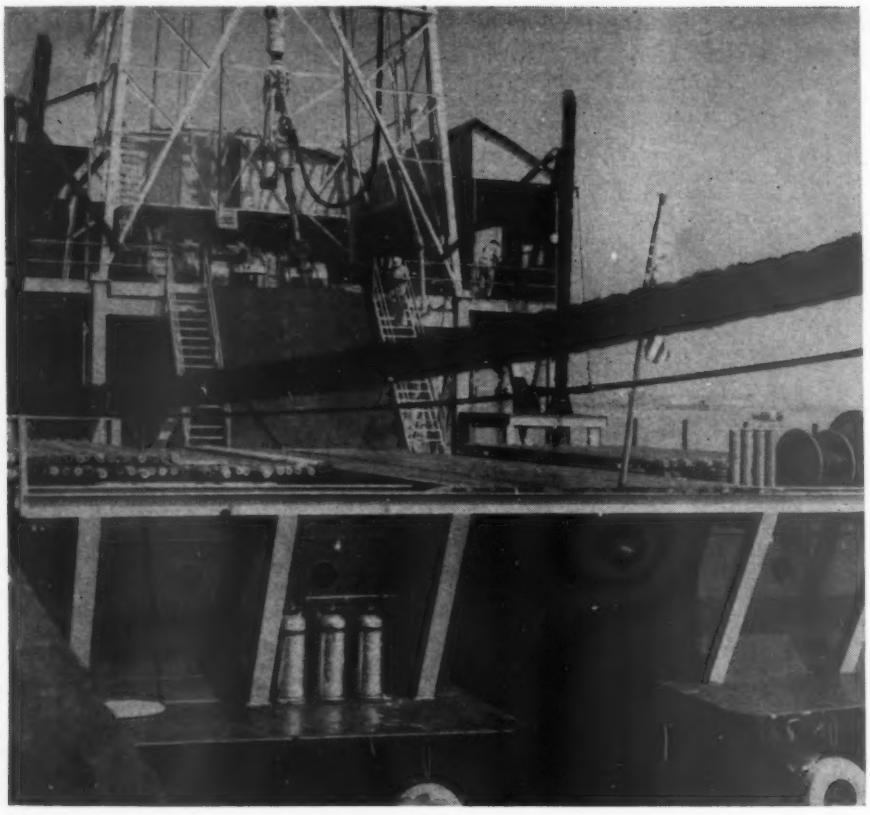
Completions

Even in 1929 the earlier practice of drilling in with the well flowing was generally considered a poor operation. Little thought was given the adverse effects of water on producing formations, however, and any mud with weight adequate to control formation pressure was considered suitable for a completion fluid. Earlier, work had been done with acid for improving delivery from carbonate rocks, in fact, well treatments had been made before the turn of the century. It was in 1929, though, that hydrochloric acid was successfully used to improve performance on an injection well and 1931 when an inhibited acid was put into an oil well. Progress in the chemical treatments of wells since that date has been remarkable. Surface tension agents, fluorides, surfactants, demulsifying agents, and corrosion inhibitors all appeared early. Improvement in pumps and connections permitting acid injection into tight formations under high pressures were developed and acidizing rapidly became the important completion tool it is today.

Future improvements in the techniques of simple acid injections are apt to be limited to the development of better inhibitors and retarded acids that will achieve deeper penetration into the formation before spending themselves.

These are relatively unimportant when considered in conjunction with the promises of fracturing with acid, a development with a great deal of future possibility.

The various fracturing processes developed in the late forties might be considered an outgrowth of both cementing and acidizing in that the high



Water operations loom large in the scheme for future drilling programs.

pressure equipment developed for these services most certainly is required. This process is of too recent a development and has been too widely documented to need further discussion. Without doubt it has added tremendously to the recoverable reserves of the nation. Probably in conjunction with secondary recovery processes it will continue to grow in importance in the coming years.

It is probable that fracturing will exert a considerable influence on well spacing in the future. Even today in certain areas 80-acre spacing is considered normal where a very few years ago even 40-acre spacing was questioned as being an effective drainage pattern.

Completion fluids, as well as drilling fluids, continue to receive merited attention. The true importance of reduction or prevention of water blocks in producing sands is daily emphasized in operations. Much progress in reducing existing blocks has been made in the field of chemical treatment. Attention to factors causing these blocks and their elimination during drilling should receive additional work in the future.

Surface Equipment

Gone are the days of the open earthen pits for lease storage of crude oil. Modern tankage conserves gravity, reduces fire hazards, and eliminates seepage loss. Treating of emulsions is no longer the haphazard and wasteful process it once was either, with modern chemicals and treating equipment operating together to reduce costs and preserve the quality of the oil.

Perhaps the greatest advancements in surface production equipment are seen in that designed to handle today's high pressure gas condensate production. Two rough groupings may be made of this equipment, one where a desiccant is used to dehydrate produced fluid before hydrate formation, the other where water is removed by lowering well fluid temperature. Both systems are marvels of modern technique and, indeed, have little counterpart in equipment that was in use 25 years ago.

The art of artificial lift has progressed as all other industry phases. In the field of rod pumping, perhaps the long stroke hydraulic unit will assist in solving the coming problems of artificially lifting deeper wells. Gas lift has made remarkable strides in recent years in improved lift efficiency and stamina of equipment. Technological advances in design of installation and selection of lift technique are also seen. Particularly worthy of note is the development of the equipment that makes possible the replacement of flow valves by wire lines.

Hydraulic subsurface units of greatly improved design are now available for general use. It must be noted that these, too, are potentially an answer to the eminent problem of economically producing deep wells.

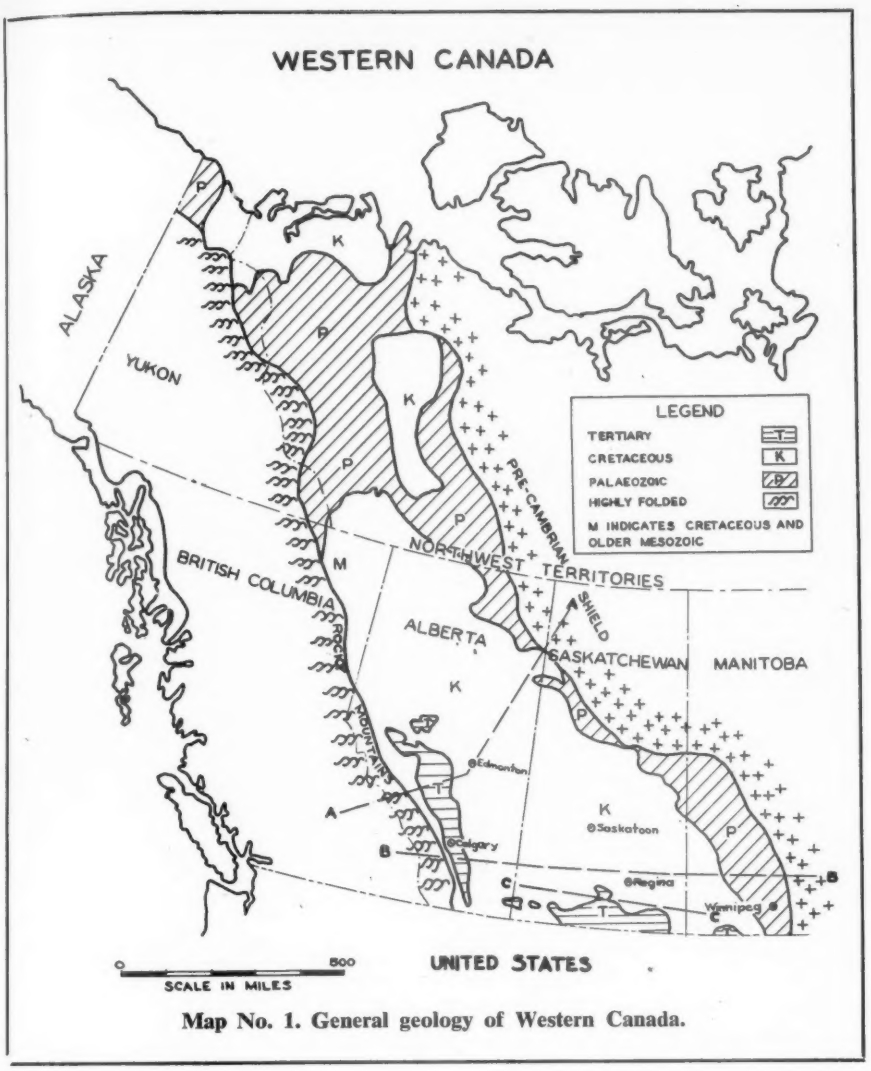
Secondary Recovery

Almost 20 per cent of today's production comes from fields under pressure maintenance or repressuring programs and these techniques have added millions of barrels of oil to this nation's recoverable reserves. History of this method goes back to the late eighteen hundreds when both gas and water were injected in fields of New York and Pennsylvania. The middle thirties, however, saw the real beginning of the era of intensive application of injection practices. In 1932, fields being operated in this manner produced about 45,000,000 bbl of oil. Twenty years later, this type production accounted for 390,000,000 bbl of oil, an increase of nearly 900 per cent. The present outlook is for continued expansion in this field. Extensive research being conducted by both industry and government is aimed at increasing the yield from depleted and semi-depleted fields. Much promise is seen in tests of various detergents and other chemical additives for more thoroughly cleansing the producing formation. Tests of gas injection under extremely high pressures has been encouraging.

Very recently experiments utilizing high temperatures — actually burning a part of the residual crude in the formation—have been conducted with good results. In short, the whole field of secondary recovery is one presently receiving a great deal of attention. It is highly probable that improvements in methods and applications will lead to the ultimate recovery of a high percentage of what is now classed as unproducible crude.

Conclusion

It is, indeed, presumptuous to attempt a review of 25 progressive years of drilling and producing activity in a few pages. Obviously, the subject can only be superficially examined under these conditions. This brief summary is sufficient, however, to show the tremendous forward strides that this vital industry has achieved and to predict that its continued growth is virtually assured. With any kind of reasonably healthy economic conditions and under the impetus of free enterprise and competition, we shall continue to move forward. Our bits will drill more deeply when the need to do so is economically justified, our equipment will continue to improve, more economical means of producing and handling our oil will evolve, and an increasingly small percentage of our discoveries will be classed as unrecoverable and left behind. * * *



Map No. 1. General geology of Western Canada.

Petroleum Geology of Western Canada

F. H. EDMUNDS

Western Canada is comprised of three main physiographic and structural elements. These are the Mountain and Plateau areas extending from the Rocky Mountain front west to the Pacific Coast and north through the Yukon to the Arctic, the Central Plains area of sedimentary rocks, and the area of the Precambrian shield. The foothill belt, which borders the eastern front of the Mountain belt, and the Central Plains are the areas in which the oil and gas discoveries and developments of Western Canada have been made and, therefore, are the subject of this article. Explorations have been made in parts of the coastal area of British Columbia and also in some of the Plateau and valley areas of that province where there are considered to be oil and gas possibilities, however, no discoveries have been made up to the present.

The sedimentary area is a tract extending about 1600 miles from the International Boundary to the Arctic Ocean with a width of 800 miles in the south and narrowing to the north. It has an area of about 750,000 sq miles and occupies the southwest part of Manitoba, approximately the southern two-thirds of Saskatchewan, all but the northeast corner of Alberta, northeastern British Columbia, the east part of the Yukon and the west part of the Northwest Territories. The most accessible and, therefore, the best known part of the belt lies in the prairie areas of Manitoba, Saskatchwan, and Alberta, and is contiguous with the states of North Dakota and Montana.

The geological features of the southern plains of Western Canada were first examined by Dawson in 1873 and 1874, and by McConnell in 1883 to 1885. These members of the Canadian Geological Survey recognized the general similarity of the conditions to those described in 1862 by Meek and Hayden for the country to the south. Following the explorations of Dawson and McConnell more detailed work, stratigraphic and structural, was done mostly by members of the Geological Survey.

After the discovery of the Turner Valley field, southwest of Calgary in 1914, however, more oil company geologists made notable contributions. Turner Valley is in the foothills, consequently most attention was paid to that belt, however, slow but steady work was progressing in the plains area where a few discoveries were made. The first spectacular one was in 1947 when Leduc was discovered. Leduc was the spark that lit the prairie fire of exploration activity and resulted in the accumulation of much more knowledge about the geological conditions. Some of the knowledge is still in the oil company files but much has been published. The bibliography given at

The Author

F. H. Edmunds is professor of Geology at the University of Saskatchewan, Sasktoon, Canada. He received his BS degree in petroleum technology and his MS in geology from Liverpool University. He came to Saskatchewan as assistant professor of soils. After joining the Geology Department he carried out various investigations and surveys for the Department of Natural Resources and recently has done consulting work relating to oil and gas exploration and development. In 1952 he was appointed a member of the Saskatchewan Oil and Gas Conservation Board.

EXCLUSIVE

the end of this article is a very restricted one and the author regrets that many valuable and important references are not mentioned because of lack of space.

Geology

Sediments of all the geological systems from the Cambrian to the Quarternary are represented in the "Sedimentary" area of Western Canada. Quarternary deposits are chiefly glacial and most of the country has a veneer of drift. The drift varies in thickness up to as much as 700 ft. It effectively obscures the bedrock in most parts of the prairies. The foothills belt and parts of southern Alberta and Saskatchewan are exceptions and in those parts outcrops are not common. In other parts isolated outcrops are to be found but they are rare and rarely of importance in determining local structures. The slow rate of exploration in the early years can be attributed, to some extent, to the fact that the drift obscures the bedrock and makes surface mapping of relatively little value in most places. As noted above most of the early exploration was in the foothills where outcrops can be mapped and attempts at structural interpretations can be made.

The "Table of Formations" (Table 1) gives the stratigraphic sequence found in five areas of Western Canada. It will be noted that there is variation in the nomenclature and some different formation names are used in different areas. This variation is to be expected because long distances between areas are involved and correlations from one to another are not absolute. The table does not, by any means, give a complete listing of formations or type sections. There are natural differences of opinion among workers and complete agreement with regard to nomenclature does not exist, however, very definite steps are taken by local geological societies to preserve as much uniformity as possible.

Map No. 1 gives the general distribution of the sequences and shows the elongated north northwest to south southeast trending basin-like structure of the region with Tertiary and Mesozoic in the central part overlying Palaeozoic on the east and north. The Palaeozoic in turn lies on top of the Precambrian but in a few places is overstepped by the Cretaceous, which then lies directly on the Precambrian. On the west side of the region both Meseozoic and Palaeozoic rocks have been involved in the mountain building movements, and separation of them can only be shown by large scale maps.

Numerous cycles of subsidence, sedimentation, emergence, and erosion

TABLE 1. Formation chart — Western Canada.

	Age	Southern Foothills	Northern Foothills	South Central Alberta	Southeast Saskatchewan	Northwest Plains Alberta and British Columbia
CEN.	Tertiary	Porcupine Hills	Paskapoo	Paskapoo	Ravenscrag	
MESOZOIC	Upper Cretaceous	Willow Creek	Brazeau	Edmonton	Frenchman	
		St. Mary River			Whitemud	
					Eastend	Wapiti
		Bearpaw		Bearpaw	Bearpaw	
		Belly River		Oldman Foremost	Belly River / Riding Mountain	
		Wapiabi	Wapiabi	Pakowki Milk River	Lea Park	Smoky River
		Big Horn (Cardium)	Big Horn (Cardium—	Colorado (Alberta)	(Cardium) 1st White Specks 2nd White Specks Fish Scale Zone	Bad Heart(Cardium)
						Kaskapau
		Blackstone	Blackstone			Dunvegan
					Bow Island-Viking	Shaftsbury
	Lower Cretaceous	Crowsnest	Mountain Park	Blairmore or Manville	Blairmore or Swan River	Peace River
			Luscar			Loon River
		Blairmore	Cadomin			Gething (McMurray)*
		Kootenay	Nikanasin			
	Jurassic	Fernie	Fernie	Ellis	Vanguard (Swift J.1)	
					Shaunavon J.2A / J.2B	Fernie
					Gravelbourg J.3 Watrous J.4	
	Triassic	—	Schooler Creek	—	Spearfish ?	Pardonet beds
			Spray River			Liard
						Toad
						Grayling
	Permian-Pennsylvanian	? Rocky Mountain	—	—	—	Both may be present (Kindle)
PALEOZOIC	Mississippian	Rundle	Rundle	Rundle	Charles	Mississippian
		Banff	Banff	Banff	Mission Canyon	
					Lodge Pole	
		Exshaw	Exshaw	Exshaw	Exshaw-Bakken	
	Upper Devonian	Palliser	Palliser	Wabamun (D1)	Qu'Appelle Group / Lyelton	
		Alexo	Alexo	Winterburn / Graminia		
				Calmar		
			Mount Hawk	Nisku (D2)	Nisku equiv.	
		Fairholme		Woodbend / Ireton-Leduc D3	Sask. Group / Duperow	
			Perdrix	Duvernay		
				Cooking Lake		
			Flume	Beaverhill Lake	Manitoba Group / Davidson Souris Evaporite	
					River 1st Red	
					Dawson Bay	Ramparts
	Middle Devonian	? Ghost River	Elk Point	Elk Point	Elk Point Group / 2nd Red	
					Prairie Evaporite	
					Winnipegosan Ashern	
	Silurian				Stonewall	Ronning
	Ordovician				Stony Mountain	Sunblood ?
					Red River	
					Winnipeg	? Mount Selwyn
	Cambrian	Cathedral ?	(Undivided)	(Undivided)	(Undivided)	
	Pre-Cambrian					

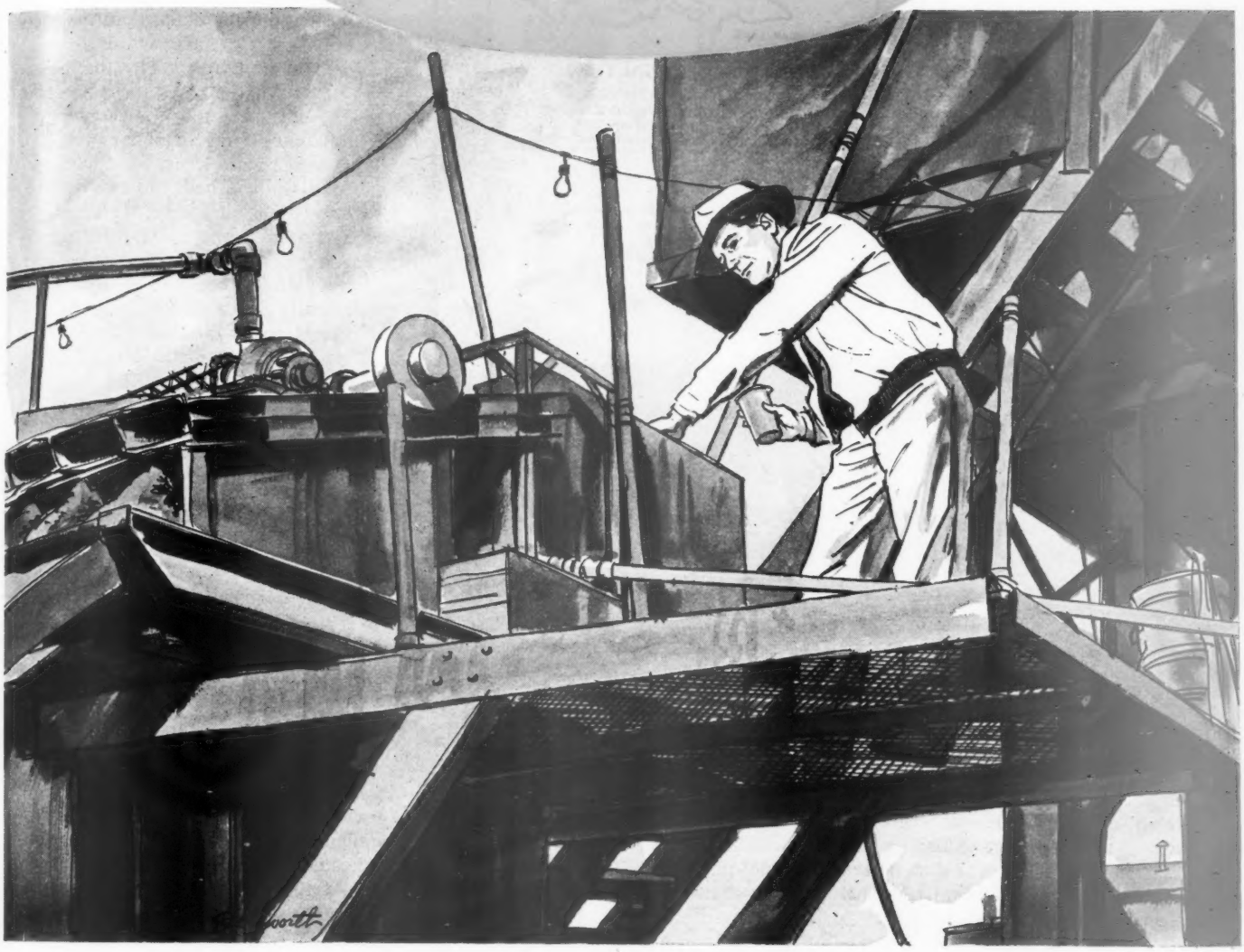
*McMurray formation of the East Athabasea Valley carries the oil Sands.

are the characteristic features in the history of the region. The differences in movements from place to place, and time to time, are now being revealed by study of the data obtained from wells. It is these differences that have resulted in the sedimentation conditions and structures suitable for oil and gas accumulations. Only a few points with regard to the regional history can be given here but for further information and detail, reference can be made to the work of McLearn, Russell, Webb, and others.

Map No. 2 shows the main structural features of the region and also the total thickness of Mesozoic and Palaeozoic sediments underlying the Plains area. Thickness in the foothills and mountain belt are still greater and probably exceed 25,000 ft in places.

During Early Paleozoic time the greatest subsidence and thickest sedimentation was in the Cordilleran geosyncline, which is now the Mountain belt. To the east of the geosycline, now the plains, relatively thin shelf deposits were formed. The most striking example of this is given by the Cambrian sediments, which are more than 20,000 ft thick in the Central Rockies, thinning to about 2000 ft in the Front

WHO DO YOU THINK HE'S WORKING FOR?



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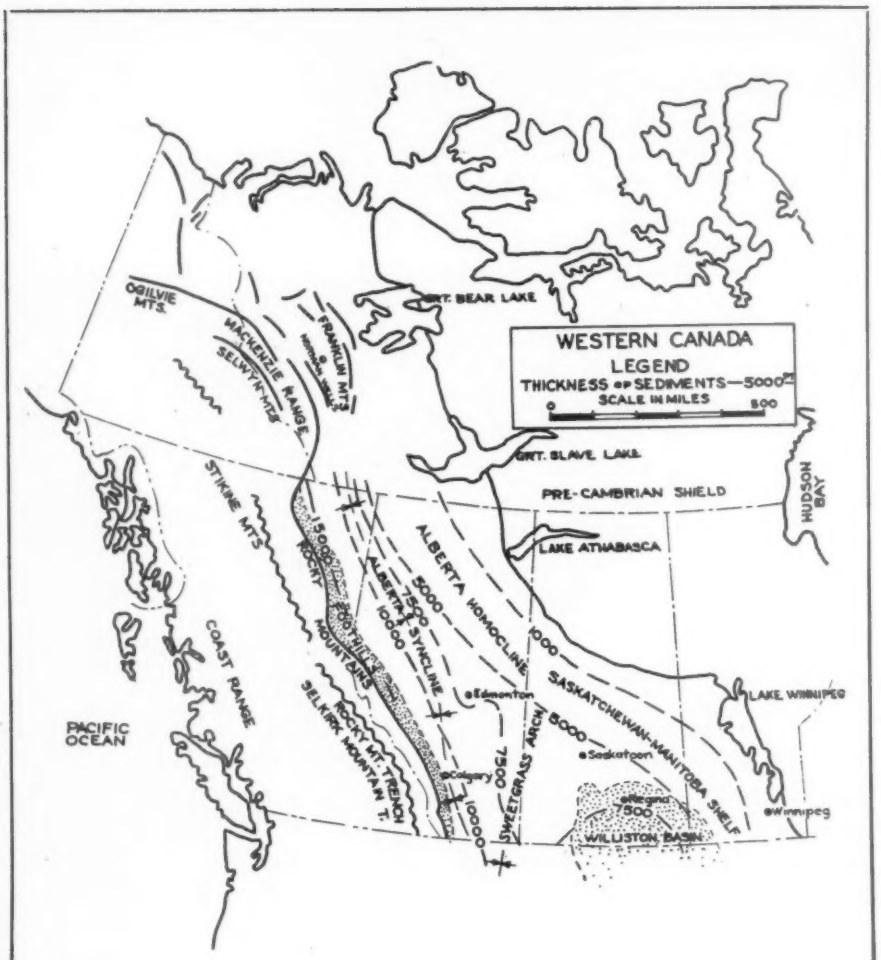

Map No. 2. Showing main structural features and total thickness of sediments.

Ranges and thence extend eastward as a relatively thin wedge of shelf deposits. No Cambrian sediments are present in the Palaeozoic outcrop area of Manitoba. The Cambrian sediments in the plains areas are mostly clastics—shales, silts, and sandstones of variable colour—limestones become more prevalent in the west.

Cambrian deposition was followed by emergence and erosion, which was in turn followed by submergence in the Ordovician. The present distribution and thickness of the Ordovician, as determined by drilling, suggests a relative downward movement in the Williston Basin area and possibly emergent conditions in southern Alberta in the area of the present Sweetgrass Arch. Thicker sedimentation took place in the Cordilleran geosyncline but probably erosion removed Ordovician sediments from the area of the Front Ranges and Foothills where Devonian beds directly overlie Cambrian. In the Manitoba area there are outcrops of Ordovician, and quartz standstones are the basal beds lying on top of Precambrian and are overlain by limestones and dolomites. One of the best known building stones of Western Canada is the mottled dolomitic limestone quarried at Tyndall a short distance southeast of Winnipeg.

Evaporites, including thick salt beds and in places potash salts, are a notable feature of Middle Devonian deposits in the prairie region. The evaporite belt, 100 to 200 miles wide, underlies the plains extending from the Northwest Territories in a south southeasterly direction across northwestern Alberta, central Saskatchewan, and into North Dakota. The salt beds in many places are more than 400 ft thick. Structures interpreted as due to salt solution followed by collapse are present in some Saskatchewan areas.

In Upper Devonian time there was a relatively thick accumulation of limestone and other sediments. Biohermal and biostromal reefs, some of which are now oil reservoirs are an important feature. Upper Devonian rocks are not present in the Manitoba outcrop area but are represented by more than 2000 ft of dolomitic limestones in the Rocky Mountain area where the Palliser is a prominent cliff-forming limestone. Subsequent erosion of part of the Upper Devonian in east central Alberta and central Saskatchewan has resulted in Cretaceous beds overlying the truncated erosion surface.

Mississippian in Mountain Area

Distribution of Mississippian sediments is more restricted than the Devonian; 2000 to 3000 ft are present in the Mountain area where the upper part of the Rundle limestone is another striking cliff-former. At Turner Valley in the foothills the Rundle is the important oil reservoir. In Saskatchewan the Mississippian beds are confined to the south part and their distribution, in a general way, marks the north boundary of the Williston Basin. Type outcrop sections of the Mississippian as found in Saskatchewan, namely the Mission Canyon and Lodgepole formations, are in the Little Rocky Mountain area, which is an uplift area lying about 50 miles southwest of Malta, Montana, and 100 miles south of the Saskatchewan border. In southeastern Saskatchewan and southwestern Manitoba the Mission Canyon and Lodgepole formations have become important because of the number of recent oil discoveries.

Pennsylvanian, Permian, and Triassic sediments are present in the Rocky Mountain and Foothill belts and underlie a fairly wide area east of the mountains in northeastern British Columbia and the Peace River country of Alberta. They are absent in the southern plains area of Alberta and in all of Saskatchewan and Manitoba. Oil and gas has been found in Permo-Pennsylvanian and Triassic strata in the above indicated northern plains area.

Jurassic beds are distributed in the Rocky Mountain and Foothills and underlie the western part of the plains. They are restricted and thin in the southern Alberta plains but are more extensive farther east and are thicker in southern Saskatchewan and southwestern Manitoba. Oil has been obtained in the Jurassic of southern Alberta for a number of years and recently fields of medium gravity oil of this age have been discovered in southwestern Saskatchewan.

Sedimentation in Cretaceous time was largely influenced by intermittent orogenic movements that took place in the country to the west. These movements started in Late Jurassic (Nevadan) and reached a culmination in the Laramide Revolution of Tertiary times. The thrusting and folding that gave rise to the structure of the Front Ranges and Foothills were probably Eocene. During the Cretaceous, delta and alluvial plain sediments spread

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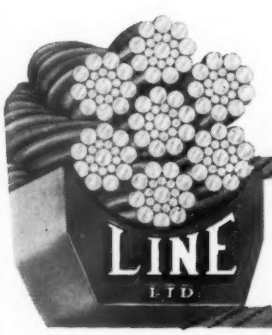

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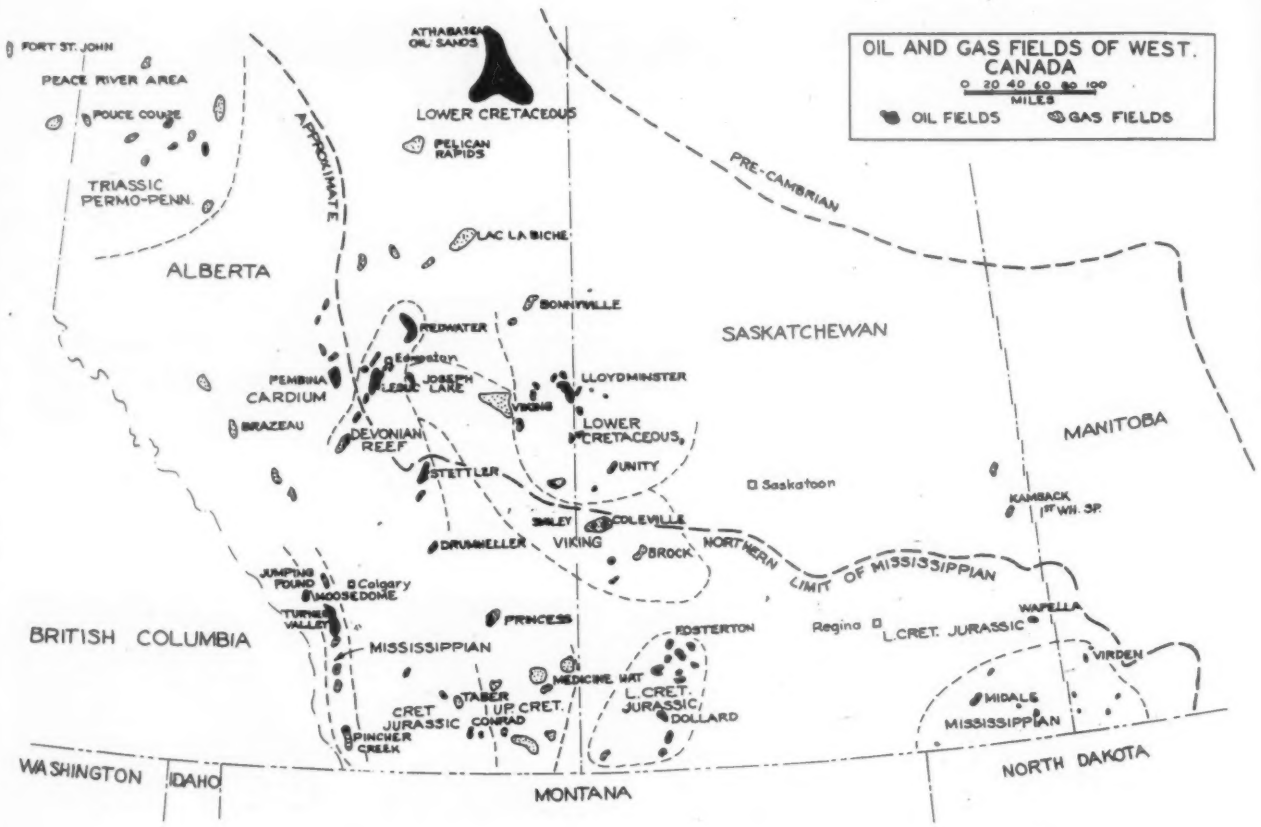

Map No. 3. Principal oil and gas fields with indication of the geological age of reservoirs.

from the west and are interbedded with marine sediments. The marine sediments were deposited in the fluctuating sea that in Upper Cretaceous time extended from the Arctic Ocean to the Gulf of Mexico.

Lower Cretaceous deposits are mostly non-marine sands, silts and shales with interbedded conglomerates. The sea was gradually spreading from the north and in the northern plains and in central Alberta and Saskatchewan the marine sediments are interbedded with non-marine. The Upper Cretaceous are mostly marine shales but in the western part of the region alluvial deposits of fresh and brackish water origin, such as the Milk River and Belly River interdigitate with the marine shales.

Many horizons of both the Lower and Upper Cretaceous have given evidence of oil and gas. The McMurray oil sand is representative of one of the lowest horizons and the Upper Cretaceous Cardium sand is one of highest and is the horizon in which the light oil of the Pembina area, about 70 miles west southwest of Edmonton, has been discovered recently.

The latest Cretaceous and earliest Tertiary deposits are non-marine with their greatest thickness in the Alberta syncline area where they are known as the Paskapoo. They extended far to the east and in southern Saskatchewan are represented by the Ravenscrag (Fort Union).Tertiary deposits of Eocene and later time are local in origin and usually thin. In nearly all parts of the region erosion was the dominant agent throughout most of the Tertiary.

Oil and Gas Horizons

The distribution of some of the main oil and gas fields is shown on the map of the Prairie Provinces (Map No. 3). Only those fields to which subsequent reference is made have been named on the map. The geological age, or horizon, from which the main oil or gas production is obtained in the fields of certain areas, is shown. The lines delineating the areas are generalized and do not imply that there is necessarily any restriction to production of the particular geological age. There may be several productive horizons in

TABLE 2. Principal Oil and Gas Horizons and Representative Fields.

System	Formation	Horizon	Representative field and location	Approx. depth of pay, ft	Type
Cretaceous	Milk River	Milk River sand	Suffield, 130 miles SE Calgary	975	Gas
	Colorado	Medicine Hat sand	Medicine Hal 160 miles SE Calgary	1000±	Gas
	Colorado	Cardium sand	Pembina, 70 miles SW Edmonton	5500±	Oil, 38° API
	Colorado	Viking sand	Viking-Kinsella, 80 miles SE Edmonton	2100	Gas
	Colorado	Viking sand	Joseph Lake, 20 miles SE Edmonton	3250	Oil, 36° API
	Blairmore	Sparky sand	Lloydminster, 140 miles E. Edmonton	2000	Oil, 14° API
		Ellerslie sand	Whitemud, 10 miles SW Edmonton	4000	Oil
		McMurray sand	McMurray, 230 miles NE Edmonton	Surface	Oil sand
Jurassic	Sawtooth	Ellis sand	Conrad, 150 miles SE Calgary	3100	Oil, 26° API
	Vanguard	Roseray	Fosterton, 160 miles west Regina	3500	Oil, 24° API
Triassic and Permo-Penn.			Fields in Peace River Area, 250 miles NW Edmonton	4000±	Gas and oil
Mississippian	Rundle	Dolmite	Turner Valley, 40 miles SW Calgary	8000±	Oil, 35° API
	Lodgepole	Limestone	Virden, 170 miles west Winnipeg	2400	Oil, 34° API
	Mission Canyon	Limestone	Midale, 90 miles SE Regina	4650	Oil, 27° API
	Bakken	(Banff) sand	Coleville, 120 miles SW Saskatoon	2700	Oil, 14° API
Devonian	Winterburn	Nisku, Dol. (D2)	Leduc, 20 miles SW Edmonton	5000	Oil, 40° API
	Woodbend	Leduc, Dol. (D3)	Leduc, 20 miles SW Edmonton	5300	Oil, 40° API

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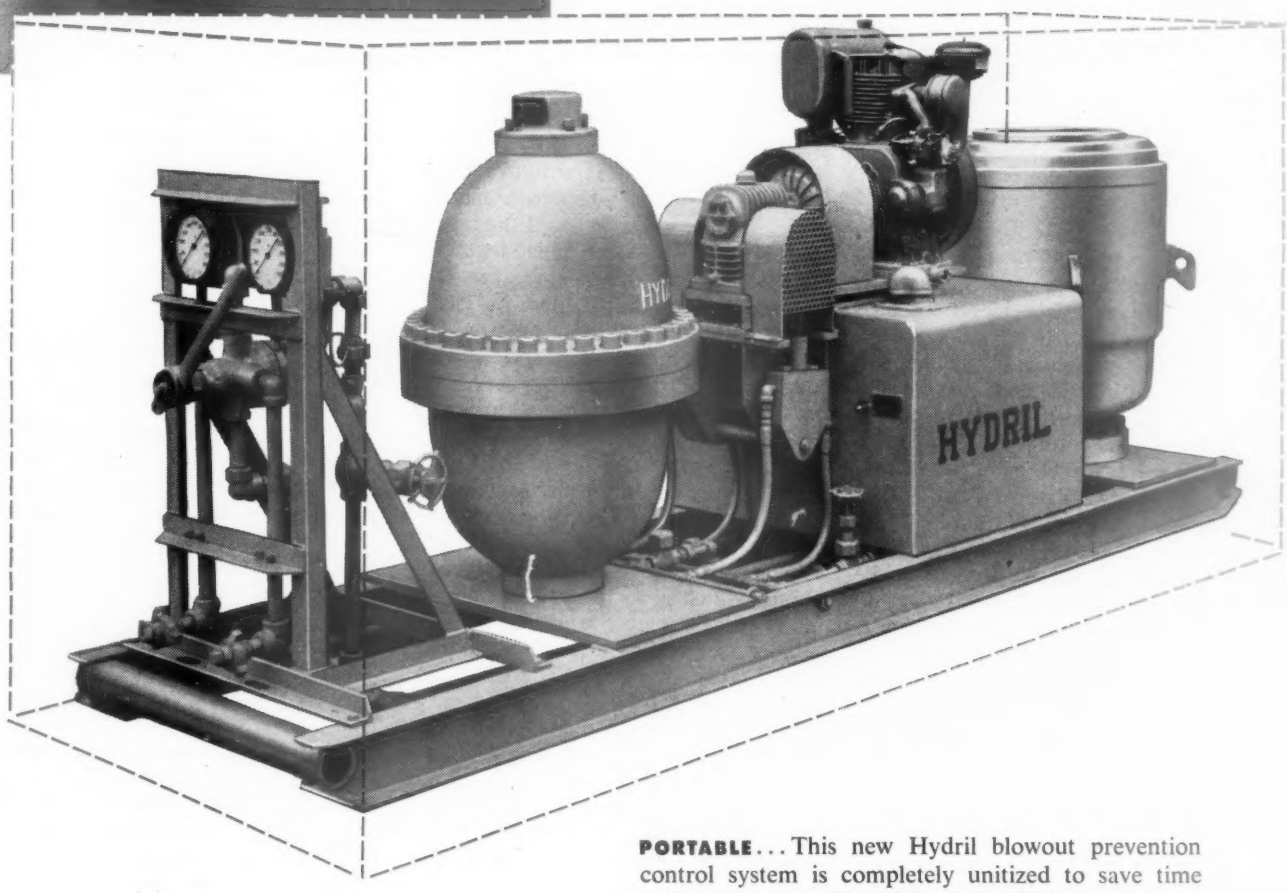

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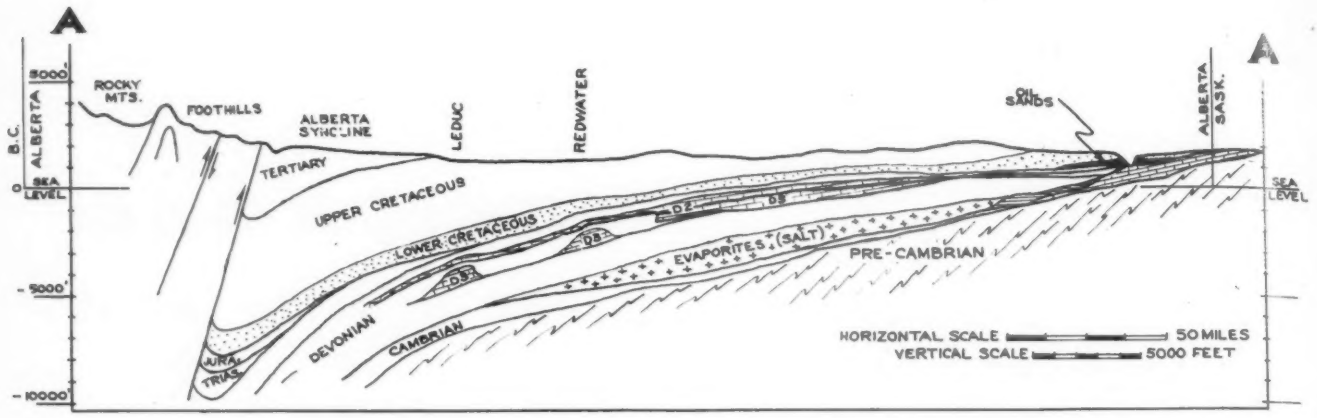

FIG. 1. Section A-A showing development of reef limestones adapted from Link.

some areas with possibilities of other yet undiscovered horizons. Table 2 lists the principal producing horizons and representative fields.

Cretaceous

Formations above the Colorado shale have given little evidence of oil or gas; however, scattered water wells in the prairie region have yielded a little gas from the Eastend, Lea Park, and Belly River formations, respectively, but not in commercial amount. Gas in small quantity is fairly widespread in the Milk River sandstone of southeastern Alberta. A number of farms obtain gas from this source and Milk River gas from the Suffield field supplies a limited local demand.

The Colorado group and equivalent shale formations underlies nearly the whole of the sedimentary region. Sands interbedded with the Colorado shale are important horizons and supply a great deal of the gas used in the prairie towns and cities. The very small gas field at Kamsack in eastern Saskatchewan is unique, in that the gas is present at the top of the Colorado in the horizon as the "First White Specks." No sand is present and the reservoir is a brown friable clay interbedded with a grey speckled calcareous shale. The depth of this horizon is about 180 ft and the original pressure was 34 psi. Some wells gave open flow readings of as much as 250,000 cu ft per day. The field produced a limited quantity of gas but has recently been closed in, the pressure having declined to about 12 psi.

The Medicine Hat sand is relatively near the top of the Colorado and underlies the southeast part of Alberta and the adjacent part of Saskatchewan. Gas was found in this sand in 1908 and has supplied the local domestic and industrial demand since that time. The field has slight structure and the gas trap is a permiability barrier.

Cardium. In May, 1953, discovery of oil was made in the Cardium sand of the Pembina area, which is about 70 miles west southwest of Edmonton. This discovery has been hailed by many as the most important since the Devonian discovery at Leduc in 1947. The Cardium formation outcrops in the foothill belt of Alberta and in some areas is called the Bighorn, east of the foothills it underlies the bordering plains and gradually shales-out to the east. At a recent meeting of the Canadian Institute of Mining and Metallurgy in Calgary, S. R. L. Harding discussed the regional distribution of the Cardium sands. He referred to the variability, which is such that there are as many as five separate sandstone beds in some places while in the extreme south there may be only one. The thickness varies from 30 to 650 ft. Porosity pinch-out is a controlling factor of oil accumulation and the discoveries have been made a few miles down-dip from the pinch-outs. The prospects for discovery of further oil in the Cardium extend from southern Alberta to northeastern British Columbia.

Viking. The Viking sand is in the lower part of the Colorado and has long been known as an important gas sand. More recently there have been several oil discoveries, as at Joseph Lake in Alberta and in the Smiley-Coleville area of west central Saskatchewan. These discoveries have resulted in a general recognition of its importance. Gas obtained from this horizon in the Viking-Kinsella field of east central Alberta has provided a supply for Edmonton since 1923. In southern Alberta one of the first gas reservoirs to be developed was at Bow Island and the sand was given that name, it has since been recognized that the Viking and Bow Island horizons are practically equivalent.

The Viking member consists of shales interbedded with sandstones. The sandstones are often uniform over wide areas but they shale out in places and the member is then represented by shale with very thin lenses of sand. Erratic distribution of the sand is probably due to uneven subsidence at the time of deposition. Structural features that control accumulations in the Viking are varied, they include pinch-out of porous sands up dip, uneven post-Viking subsidence and differential compaction over Palaeozoic erosional features. Faulting does not seem to be a significant factor.

The Viking-Kinsella is a representative Viking gas field, located 80 to 90 miles southeast of Edmonton, with an areal extent of about 600 sq miles. The regional dip is about 10 ft to the mile to the west southwest. The top of the sand has slight undulations and the northeastern limit of the productive area is due to the gradual shaling out of the sand. In the productive part of the field the average thickness of the sand is 15 ft, connate water content is high and in estimations of reserves a figure of 45 per cent was taken by Hume and Ignatieff.

The Joseph Lake oil field is located 35 miles southeast of Edmonton and is the first one to produce oil from the Viking. The structure is anticlinal with a north northwest axis, dips are slight and may reach as high as 1 deg on the southwest flank. Horizons above the Viking show a homoclinal structure. C. Warren Hunt, who has described the field, gives his explanation of the structure as follows:

"Unequal subsidence and/or subsequent unequal uplift at the close of Viking time is the only possible and logical explanation for the very gentle Joseph Lake anticlinal structure."

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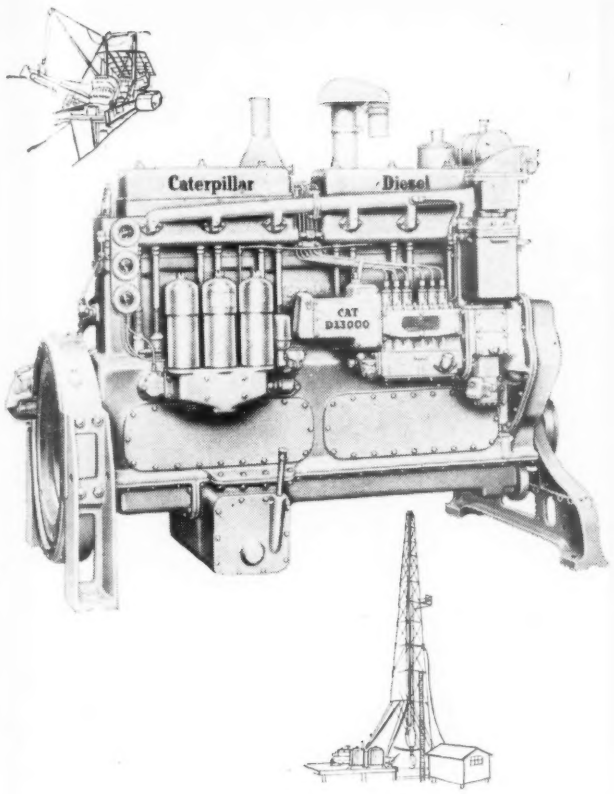

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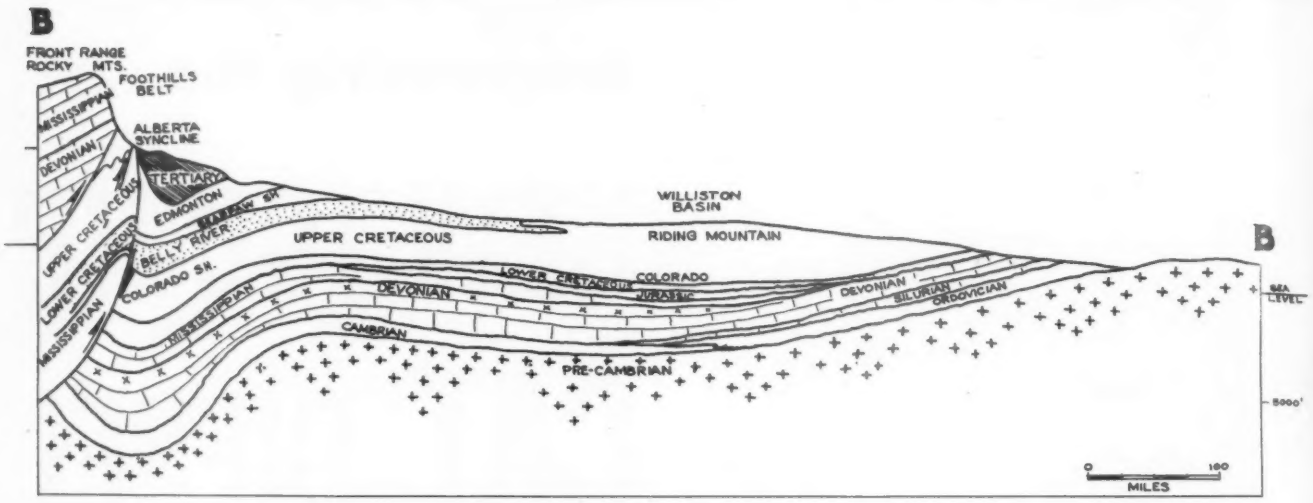


FIG. 2. Section B-B general section from front ranges across the sedimentary belt.

at Joseph Lake other Viking oil discoveries have been made. One of the most important of these is at Smiley, Saskatchewan, which is 125 miles west southwest of Saskatoon. In 1951 Viking gas was discovered at Coleville (10 miles east northeast of Smiley). On drilling about 400 ft below the Viking heavy black oil was found in a Mississippian sand, and marked the discovery of the Coleville oil field. Scattered drilling in the area showed that the Viking gas field was a relatively large anticline with an east-west axis. Oil was discovered by a west extension well near Smiley in September, 1953. The Viking sand proved to be structurally low and carried oil with a gravity of 35 deg API. Subsequently other oil discoveries have been on the margin of the gas field but oil is not present everywhere surrounding the structure. The anticline in the Viking is larger, more clearly defined, and has steeper dips than that in the underlying Mississippian sand, and it is evident that the Viking structure is due in part to differential compaction over a Mississippian erosion feature. Viking sands with good porosity are present in many parts of the prairies, particularly in the south, and are also present in east central Saskatchewan and locally reach a thickness of 60 ft. Active exploration of the Viking is expected to result in further discoveries.

Blairmore. Sands in the Lower Cretaceous have yielded oil in many parts of Western Canada — in the foothills the first oil discoveries in the Turner Valley area were in sands of the Blairmore. Oil with medium gravity has been found in southern Alberta and southwestern Saskatchewan, medium to light gravity in central Alberta where the crude is in the Ellerslie sand of

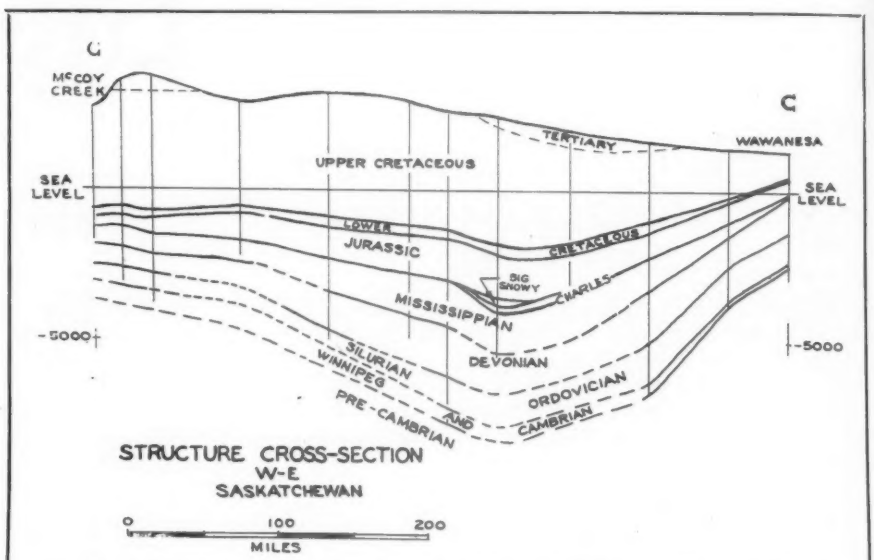
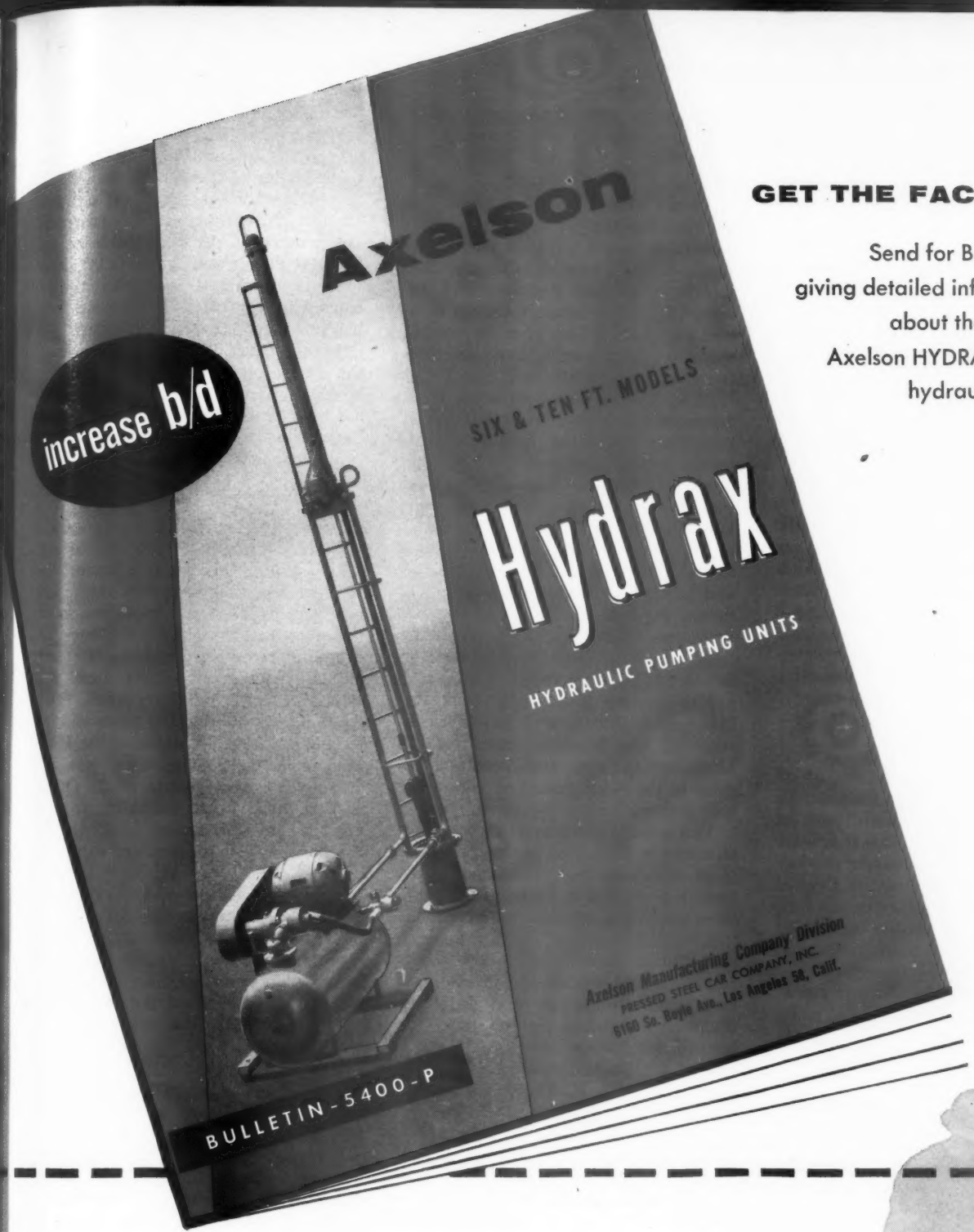


FIG. 3. Section C-C. Williston Basin adapted from Gallup and Hamilton.

the Whitemud, and other fields in the vicinity of Edmonton and Leduc. The vast reserves of oil sand at McMurray, 230 miles northeast of Edmonton, are of this age.

The McMurray oil sands are to be seen in a number of outcrops along the Athabasca river and its tributaries. The outcrops show oil saturated sand in cliffs of as much as 200 ft. Surveys indicate an areal extent for the deposit of several thousand square miles and the reserves have been estimated variously as from 100 to 300 billion barrels. The McMurray formation lies directly upon Devonian strata and is a quartz sand of deltaic origin with pronounced cross bedding. It is thought to have been derived from the Precambrian rocks that lie to the east. Much discussion has been devoted to the question of the origin of the oil and many believe that it is of Devonian source and others of Cretaceous. Recent evidence from analyses of trace elements in the oil seem to support the latter view. Many papers have been written about the oil sands and a number are published in the Proceedings of the Athabasca Oil Sands Conference, September 1951.

Lloydminster is the center of heavy black oil production in Western Canada. The town is situated on the Alberta-Saskatchewan border about 300 miles north of the International Border. There are 5 main producing pools in the vicinity of Lloydminster and another 6 at varying distances including Lone Rock, 16 miles south, Marsden, 30 miles south, Waseca, 30 miles east, the Kitscoty, 20 miles west.



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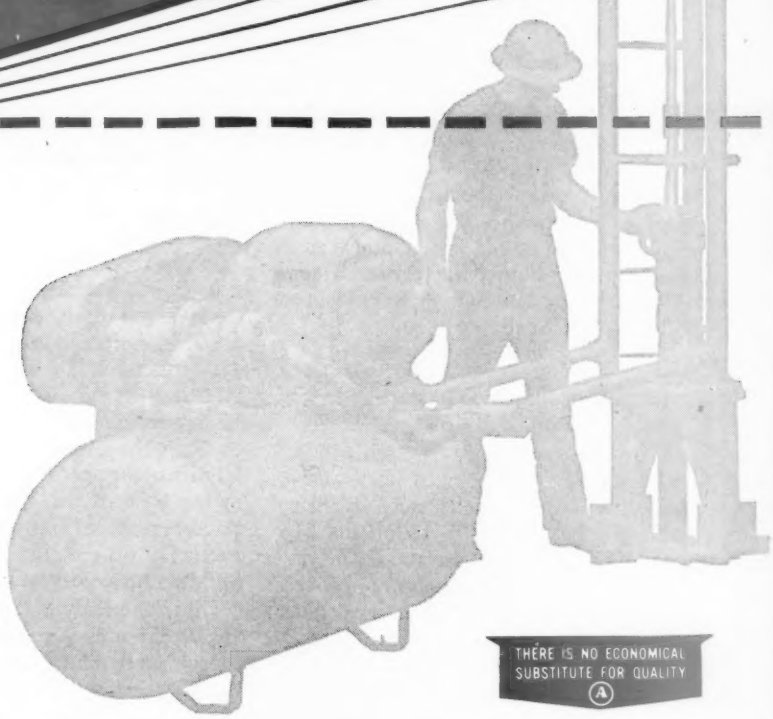

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The oil is obtained from sands in the Blairmore or equivalent Manville formation, which is at a depth of from 1700 to 1900 ft below the surface. Sands near the top of the formation are gas-bearing in places and carry a little oil, however, the main producing sand known as the "Sparky" is about 150 ft below the top of the formation. The reservoir consists of incoherent fine quartz sands with interbedded silts. The total sand content varies from a few feet to 40 or 50 ft.

The regional structure is one of dip to the southwest of about 10 ft to the mile and the main Lloydminster pools are situated on a broad terrace feature. Each pool has distinct local structure with small closure, in most cases due to differential compaction of the sediments which are of deltaic origin, the structure occurring where the sands are thickest. In some cases the local structures are likely to be the result of differential compaction overlying topographic features of the underlying Devonian erosion surface.

Jurassic

The distribution of Jurassic sediments, which have possibilities of oil production, is confined to the foothills belt, the extreme southern part of Alberta and southern Saskatchewan. In southern Alberta Jurassic production is being obtained in the Conrad field where basal members of the Ellis group lie unconformably on the eroded surface of Mississippian limestone. The irregularities of this surface have influenced the distribution and thickness of Jurassic deposition. A white quartz fine to medium grained sandstone is the productive horizon at Conrad.

Since 1952 a large number of Jurassic discoveries have been made in southwestern Saskatchewan. The first was the Fosterton field, 160 miles west of Regina. As in southern Alberta, Jurassic deposition has been influenced by the post-Mississippian erosion surface. The reservoirs are sands in the Vanguard formation and oolitic limestones in the Shaunavon (Piper). Most of the fields show complete closure with reversal of dip.

Triassic and Permo-Pennsylvania

Many discoveries of gas and oil in the Peace River country of northwestern Alberta and northeastern British Columbia have been in sediments of both Triassic and Permo-Pennsylvanian age. Little development to prove up the resources has been carried out because of difficulties of transportation and marketing. Most of the discoveries stand capped. There is little doubt with regard to the relatively great potentialities of this area.

Mississippian

Turner Valley. The classical example of Mississippian oil fields in western Canada is Turner Valley in the Alberta foothills southwest of Calgary. The structure has been described and discussed by many authors and in a recent paper T. A. Link gives the various views that have been held and describes the structure as follows:

"The Turner Valley structure is an asymmetrical, highly faulted, anticlinal structure involving Paleozoic sediments, and is underlain by a low-angle (possibly folded or warped) major sole fault on which it was carried eastardly during the Laramide orogeny. It is slightly arcuate in shape and plunges to the south into the Alberta Syncline and to the north underneath another thrust sheet involving the Paleozoic limestone, termed the Millarville thrust fault, which is topographically a north extension of Turner Valley. The oil and gas production is obtained from the biostromal limestone-dolomite horizons in the Madison limestone of Mississippian age, and accumulated prior to the development of the major sole faulting."

The general features of the foothill structure is illustrated in the cross-sections A-A and B-B. Faulting of the same type as that at Turner Valley has been mapped in other parts of the foothills.

Williston Basin. In southwestern Manitoba and southeastern Saskatchewan active drilling has resulted in the discovery of Mississippian oil in a number of fields. Recent papers on the geology of the Saskatchewan part of the basin are by G. E. Thomas who discussed the stratigraphy of the northeastern part and by W. B. Gallup and G. J. Hamilton on the orogenic history.

The cross section C-C shows the structure in this part of the basin and is taken from the latter paper. Mississippian formations recognized in this area are from the top — Charles, Mission Canyon, Lodgepole, and Bakken, the regional dip is to the southwest and post-Mississippian erosion resulted in the truncation of the formations so that subsurface outcrops of the successive formations are present. The line on Map No. 3 showing the limit of the Mississippian represents the subcrop of the base of the Bakken. The truncated surface of the successive beds is overlayed by red silts and sands of the Middle Jurassic-Watrous formations.

Oil in the Daly and Roselea fields of the Virden area is present in a massive, cherty crinoidal limestone of the Lodgepole formation. Accumulation has been controlled by local permeability barriers. The Midale field reservoir is an algal and pisotitic limestone of the Mission Canyon formation. In this field there is structural closure. Stratigraphic trap conditions are present in some of the other fields of the area. At Tilston and Waskada in Manitoba the eroded Mississippian surafce capped by impermeable Jurassic beds has provided reservoir conditions.

Mention has already been made of the heavy oil at Coleville in eastern Saskatchewan. The oil is present in sands of the Bakken formations, which have been previously referred to in the literature as Banff sand.

Devonian

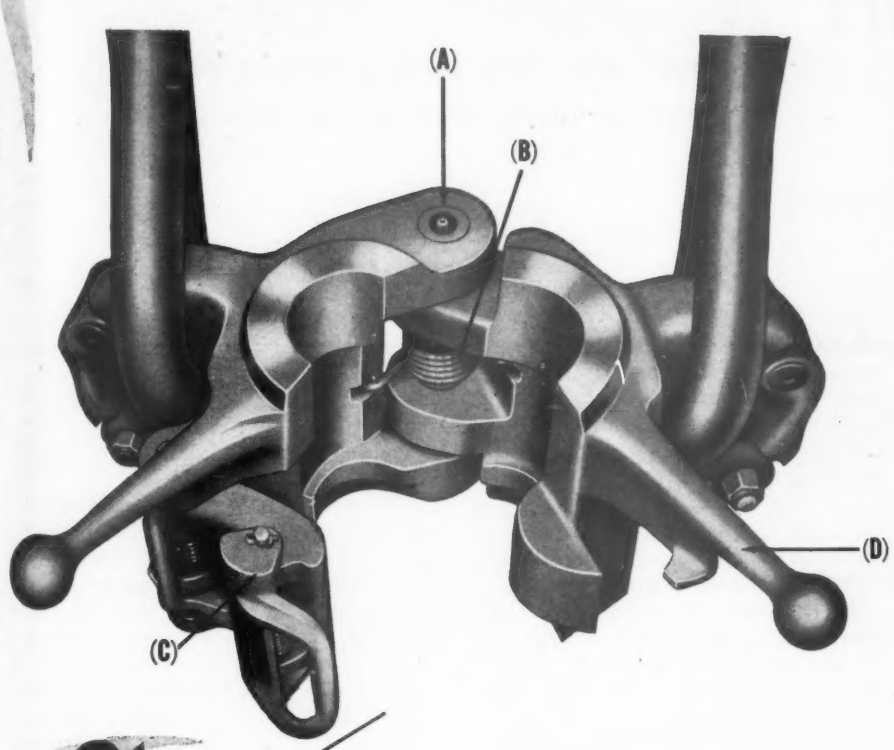
Western Canada Devonian strata are more widespread than those of any other system, except Cretaceous. In the Mountain belt relatively thick sections are exposed and examination of the outcrops has shown evidence of source material for petroleum. For example, with respect to the Sunwapta Pass area, J. L. Severson states "The coral and stromatoporoid zones and interbedded black limestones of the Fairholme could be considered possible source beds for petroleum." Other authors have made reference to the presence of bituminous material in fractures and vugs in Devonian outcrops.

Very light gravity oil (60 deg API) and gas was found in the Devonian of the Moose Dome area, which lies to the northwest of Turner Valley. Devonian oil has been produced since 1920 in the Norman Well field of the Northwest Territories, there the reservoir is a reef limestone.

The outstanding discovery of oil in the Devonian was that of Leduc in 1947. This discovery was the climax of a long and often disappointing exploration in the plains area of Western Canada, for up to that time only minor developments of medium and heavy gravity Mesozoic oil had been made. It resulted in a very great acceleration of exploration and was quickly followed by other major discoveries of Devonian oil as at Redwater, Golden Spike, and other fields in the Edmonton district and south at Stettler and Drumheller.

The Leduc oil field is on the Alberta homoclinal belt and the lowest producing reservoir is crystalline dolomite with vugs and intercrystalline porosity, there is no evidence of bedding and it is recognized as a biohermal reef. The reef is overlayed by green shale that thickens at the edges of the structure. The domal mass of the reef provides both structure and reservoir. The reef dolomite is the Leduc member of the Woodbend formation and was originally called the D3 Zone. The reef dolo-

WORLD'S BEST ELEVATOR

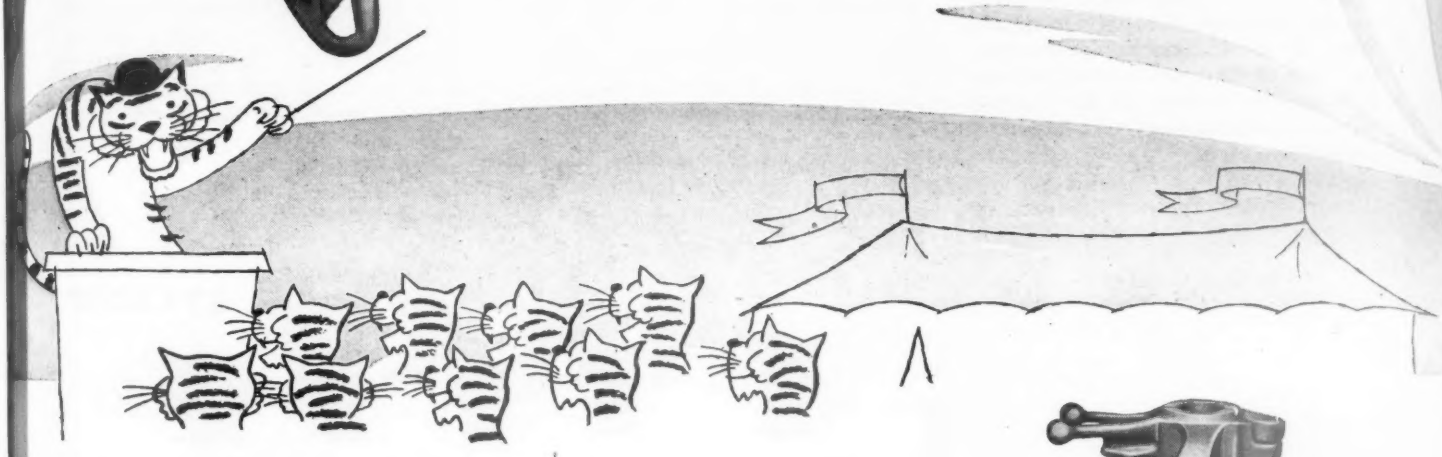


(A) This fitting (safely recessed in the hinge pin) permits proper lubrication to ensure easy opening and closing of elevator.

(B) This spring opens the elevator and forces it off and away from the pipe.

(C) The safety lock closes automatically with the latch; and one easy motion opens both lock and latch.

(D) Guards on handle protect hands from injury against the links.

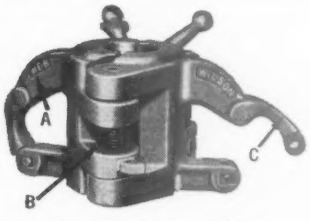


The *exclusive* features shown above are sufficient to make the Web Wilson "Balanced" Center Latch Elevator the WORLD'S BEST—and the choice of fast-moving, safety-minded crews—but there are **OTHER IMPORTANT FEATURES!** Remember that these "Balanced" elevators are made from Manganese-Molybdenum steel, properly heat treated—all pipe contacting surfaces are flame hardened to wear a long, long time—and see other advantages at right.

FOR ALL TYPES AND SIZES OF DRILL PIPE. Web Wilson "Balanced" Center Latch Elevators are available for Regular and External Upset "Collar Type" drill pipe, and also for "Bottleneck" (18-degree taper) drill pipe. Made in 12 sizes to handle drill pipe and tubing from 1¼" to 7".

YOUR supply store has Web Wilson "Balanced" Center Latch Elevators in stock—or can get one for you—pronto!

The slanted hinge pin, which provides automatic closing, is clearly seen above.



A–Rugged Link Arms fit links perfectly.
B–This spring opens the elevator and forces it off and away from the pipe.
C–Link Arms are easily operated, but are securely locked in place

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mite is more than 165 ft thick.

About 200 ft above the Leduc member and overlying the green shale (Ireton member) there is another reef dolomite, the Nisku member of the Winterburn formation. This is the reservoir generally known as the D2 Zone and is 145 to 165 ft thick. The Nisku reflects the structure of the underyling biohermal reef, also the sediments up into the Cretaceous show slight reflections of the structure due to differential compaction.

The extent of the area (or areas) that are likely to have conditions similar to those of Leduc, Redwater, and other reef fields, has not been defined. East from Edmonton the upper beds of the Devonian become truncated and before the Saskatchewan boundry has been reached the equivalent of the Leduc member has been removed by erosion and Cretaceous beds overlie still lower strata. Equivalents, however, of the Woodbend and Winterburn formations are present beneath much of southwestern Saskatchewan but oil or gas discoveries have not yet been made in these beds. Oil and gas deposits have yet to be found in beds older than the Woodbend.

Relatively few wells have been drilled to the basement Precambrian rocks. Some of those that have drilled into the Silurian, Ordovician, or Cambrian have obtained evidence of the presence of porous limestone and clastics, a few shows of oil and gas have been obtained and there is justification for further exploration of these deeper horizons.

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What Is This Sonic Drill?

New tool may help solve problems of drilling hard formations in crooked hole country

J. B. STUMM*

A CONSIDERABLE amount of conversation is traversing the oil patch these days concerning a rather unique departure from conventional oil well drilling procedure. From executive offices in the oil capitals of the country to the doghouses in our far-flung oil fields can be heard all manner of speculation regarding this fantastic device for "making hole."

Experiments with the sonic, or percussion, drill, now nearing completion in the laboratories of the Petro-Mechanics Research Division, Borg Warner Corporation in North Hollywood, California, were begun a number of years ago by Albert G. Bodine of Los Angeles, a pioneer investigator of infrasonic energy.

Infrasonic sound waves are those that vibrate below 20 cylces per second and cannot be detected by the human ear. Similarly, ultrasonic sound waves are those that vibrate above 20,000 cycles per second and likewise cannot be detected by the human ear.

There are numerous uses being developed for ultrasonic sound waves, from examining metal castings and forgings for flaws, to treating patients suffering from arthritis.

On the other hand, infrasound, when properly harnessed can produce tremendous energy. It is this infrasonic energy that is being utilized to operate the sonic drill. The multi-second vibrations created literally smash and break up the formation ahead of the bit.

Basically, the sonic drill consists of an 8½-in. diameter drill collar, approximately 150 ft long. Inside, and at approximately the center of the drill collar, is mounted a sonic generator and mud turbine drive. The sonic generator consists of two pairs of eccentrically balanced weights that rotate at extremely high speed, each on its own shaft. The pairs of weights rotate in opposite directions of each other, but all are in phase so that all four weights exert vertical thrust simultaneously while they oppose each other on the horizontal plain. Thus, in fast rotation, they create a severe up and down motion that generates a resonant action in the drill collar.

What actually happens is each end of the drill collar makes rapid elongations and contractions while the central portion remains motionless, much as the action of a tuning fork. This elongation and retraction measures less than 2 in. at each end of the drill collar. Huge coil springs are mounted at the top of the drill collar in such a manner as to prevent the vibrations from traveling up to the drill pipe. The only force utilized is that exerted at bit end.

The mud turbine drive is mounted directly above the sonic generator. Operating off the regular mud stream, the turbine drive provides the required power to operate the sound generator.

The bit is conventionally mounted at the bottom of the sonic drill collar. It is of special design, but closely resembles an ordinary "Star type" bit.

All rig equipment is conventional including rotary table. Although rotation is not necessary to the operation of the sonic drill, slow rotation is desirable to maintain a round, symmetrical hole.

Larger mud pumps may be required because of flow restrictions through the turbine drive and restricted bypasses that circumvent the operating mechanisms within the sonic drill collar.

Very little information is available from the Petro-Mechanics Research Division of Borg Warner Corporation as to their progress in this fascinating development except that they are optimistic and hope to have something available for commercial use in the not too distant future. ★ ★ ★

*Editor, Pacific Coast.

EXCLUSIVE

Besides turning the United States into a nation on wheels, oil powers the planes that make it air-borne. U. S. airlines flew a record of 18 billino passenger miles last year, a mileage equal to 40,000 round trips to the moon.

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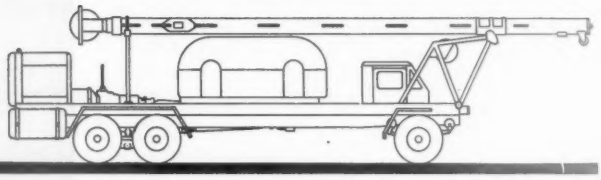
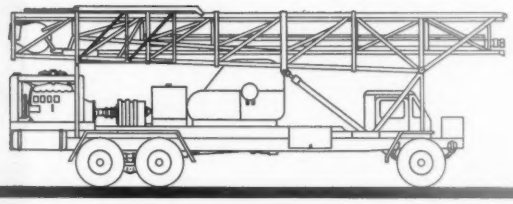


or TELESCOPING DERRICK



. . . for well servicing and workover work 4,000 to 9,000 ft.

Following the success of its heavy duty Clipper line of self-propelled units in proving faster and more economical in well servicing, rig-up, and moving, Franks has now designed a "MIDGET" CLIPPER (single or double drum) with either 65 ft. pole mast, or 66 ft. telescoping derrick.

The unit has more power than has been previously offered on a truck-mounted servicing unit of equivalent weight. It is legal in weight and in all road length and width measurements in all oil producing states.

The Midget Clipper is available with hydraulic drive for: rotary table; Guiberson Head for reverse circulation; raising and lowering derrick; tongs; air lift rod transfer available on derrick type.

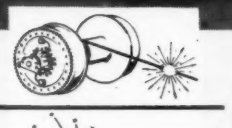
As with all Franks Clippers, the Midget affords perfect location "spotting" as it heads into location instead of backing in.

It is a unit primarily built for well servicing, although it is completely self-propelled using the industrial type power plant to move the unit from location to location.

Like all Franks equipment, the Clippers are of rugged build which assures long life and less maintenance.

Pictured is Franks Giant Clipper for deepest production.

State whether you are interested in pole mast or derrick type in writing for complete specifications on the new Franks Midget Clipper.



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Methods Improvement

first of a series

Improving Rotary Rig Operations

With drilling costs increased, better use of both machine and personnel time is needed by the contractor; intelligently applied, "job design" can accomplish this

WILSON J. BENTLEY

METHODS IMPROVEMENT: Answer to Higher Costs

Customs established years ago in the use of equipment and field operations in drilling and producing are being continued today without proper consideration or analysis. Equipment manufacturers continually design and redesign their products to increase efficiency and raise the quality of work performance. Operational methods haven't kept the pace.

The answer lies in "Job Design." Pioneered at Oklahoma A&M College, "Job Design" is effective use of men, machines, and tools.

"Improving Rotary Rig Operations" is the first in a series of exclusive articles on methods improvement in drilling and producing practices by industrial engineer Wilson J. Bentley, widely known consultant, registered professional engineer, and professor of industrial engineering, Oklahoma A&M.

Subsequent articles will cover such timely topics as tripping, well servicing, rig preventive maintenance, pumper activities, etc.

METHODS can be improved and costs can be reduced in rotary rig drilling operations. Drilling contractors need no one to tell them that drilling costs have increased approximately 90 per cent since 1945, although drilling revenue has increased only about 10 per cent. Complaining about conditions relieves personal feelings, but little for the economic situation.

During the past year, a small number of companies (including both major and small independent companies) have been successfully employing the techniques of job design to rotary drilling operations. The term, job design, describes the technique of applying the concepts of motion and time study to oil industry operations. Professors H. G. Thuesen and M. R. Lohmann, of the Oklahoma Institute of Technology at Oklahoma A. and M. College, are credited with being the pioneers in this field, and did their work primarily in oil production operations. "Job design" is thought of as being the design of the job to most effectively use the man, his machines, and his tools.

The Author

Wilson J. Bentley is associate professor of industrial engineering and management, Oklahoma A. and M. College. He has BS and MS degrees in industrial engineering from Oklahoma A. and M. He spent a year in electrical construction work and five years as an army engineering officer. Following World War II he was associated with Wilson and Company and was refinery industrial engineer for Deep Rock Oil Company.

He has served in a consulting capacity to numerous industries (including oil refining, production, and drilling) in the field of management, methods study, and job evaluation. Bentley is a registered professional engineer in Oklahoma, a member of Oklahoma Society for Professional Engineers, National Society for Professional Engineers, American Institute of Industrial Engineers, American Society of Engineering Educators, etc.

Manufacturers of drilling equipment are constantly designing and redesigning their equipment in order to increase efficiency of their product and to raise the quality of work performance. A great deal of study and time is spent on this design effort; yet, little thought is given to planning the best way to use this equipment. Customs established 20 and 30 years ago are continued without proper consideration and analysis. Investigations are showing that 10 to 50 per cent of the available work time is spent on non-productive work. In some areas, savings of as much as $20,000 annually per rig are being found possible.

Too often, methods studies are doomed to failure from the beginning because the management is looking for a "package." This package, being a set of instructions which, if applied to any rig any place, will result in savings in time or money. To be fundamentally sound, the successful application of job design must be based on four important steps.

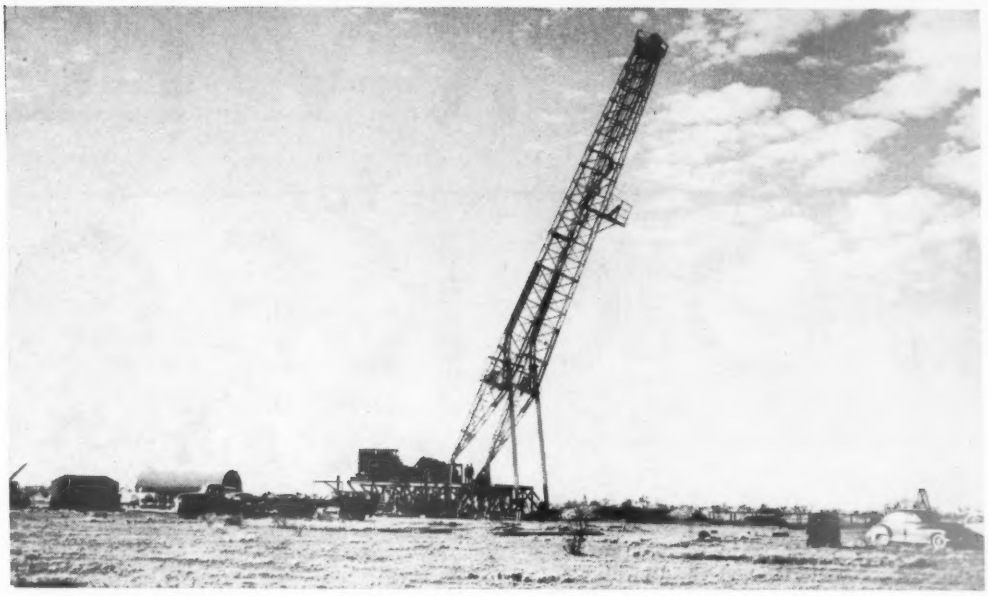
The first step is to determine the existing manner of performing the operation. This sounds quite elementary and, possibly, even foolish. "Everyone knows how we're doing the job now," is the first thought that comes to mind. Experience has shown that eye-witnessess to an accident seldom see the same thing, and similarly, people associated with the job seldom see the same thing. The recording of an overall unbiased picture of the operation is the objective in this first step.

The second step consists of placing the information obtained in Step 1 in a form that will facilitate understanding. This may be merely writing down the elements of work in their observed sequence. It may consist of the use of any one of a number of charts that are adapted to the particular situation.

The third step is the analysis of the information that has been obtained and recorded. Every element of work is questioned as to whether it can be eliminated, combined with another, simplified, or possibly, just the sequence of the work elements changed.

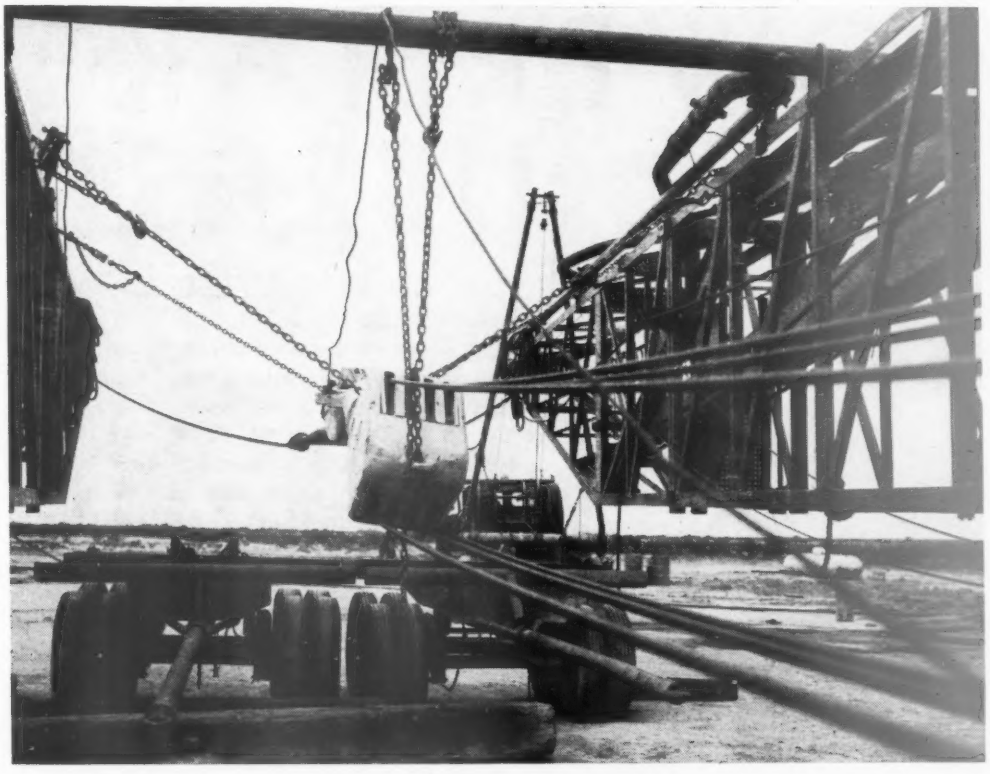
The fourth step is the design and re-building of the elements into a workable plan that can be adopted right into a regular schedule.

To successfully complete these four steps, the following conditions must exist: First, both central management

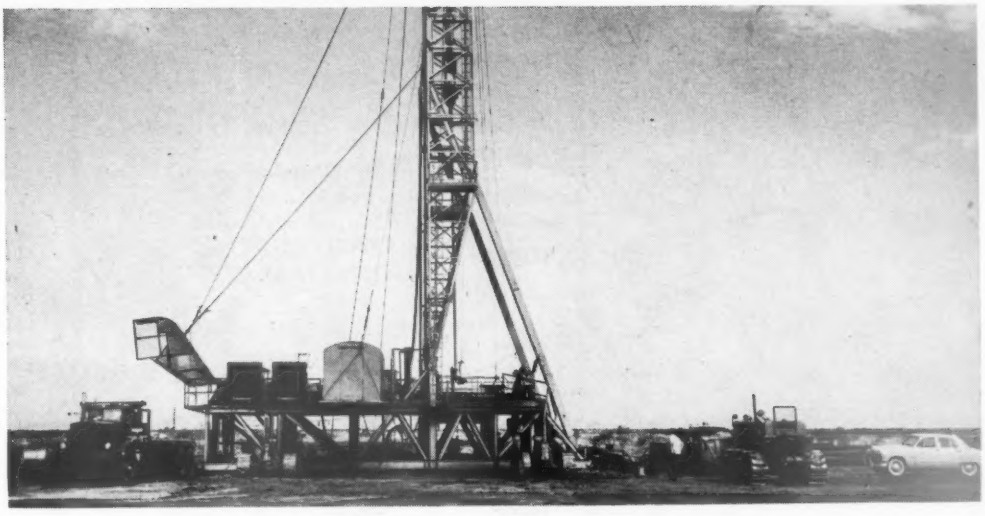


During rig moving operation more men and equipment are together than at any other period in rig operation. Rig moving can be an efficient operation only through careful planning and coordination of crew activities, a technique substantially aided by analyzing activities and improving methods. Pictured is a 133-ft full view mast being lowered in West Texas.

—Photos Courtesy Ideco.



Taking advantage of conditions can save operator money. Mast legs on twin bogey have been left in full open position during lowering, ready for immediate reattachment when mast arrives on location. Move is being made on lease road, where such operation is feasible.



Skid moving a 133-ft mast in West Texas. Each rig move is a completely different operation, and methods must be developed and planning based on individual conditions of each separate move, incorporating the best principles that have been evolved from previous experience.

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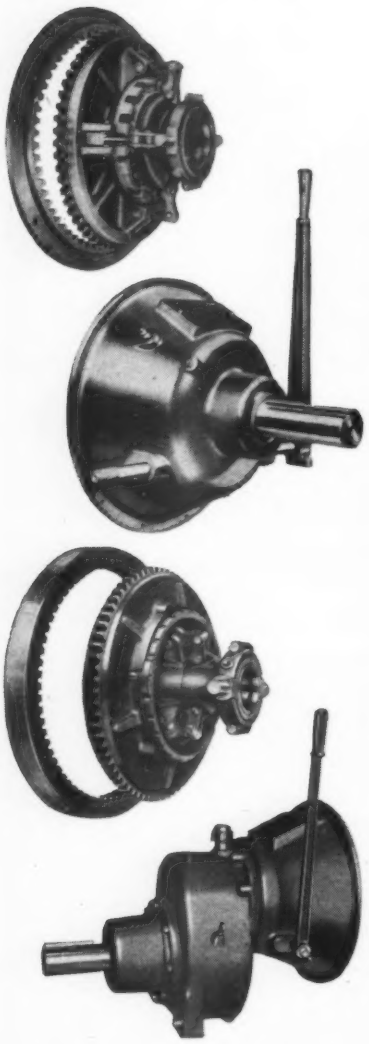

ROCKFORD Heavy Duty CLUTCHES, POWER TAKE-OFFS and SPEED REDUCERS are standard equipment on various makes of industrial engines. They are available in standard sizes ranging from 125 foot pounds to 2100 foot pounds torque. Clutch sizes range from 6½ to 18 inches, single and double plate — to fit standard S. A. E. flywheel housings. These complete, self-contained power take-off units are being used extensively for heavy duty gear-tooth drive type application to gasoline and diesel engine powered drilling, pumping and servicing rigs. Their precision manufacture, conservatively rated capacity, field proved stamina and unusual ease of adjustment are lowering upkeep costs throughout the petroleum producing areas.

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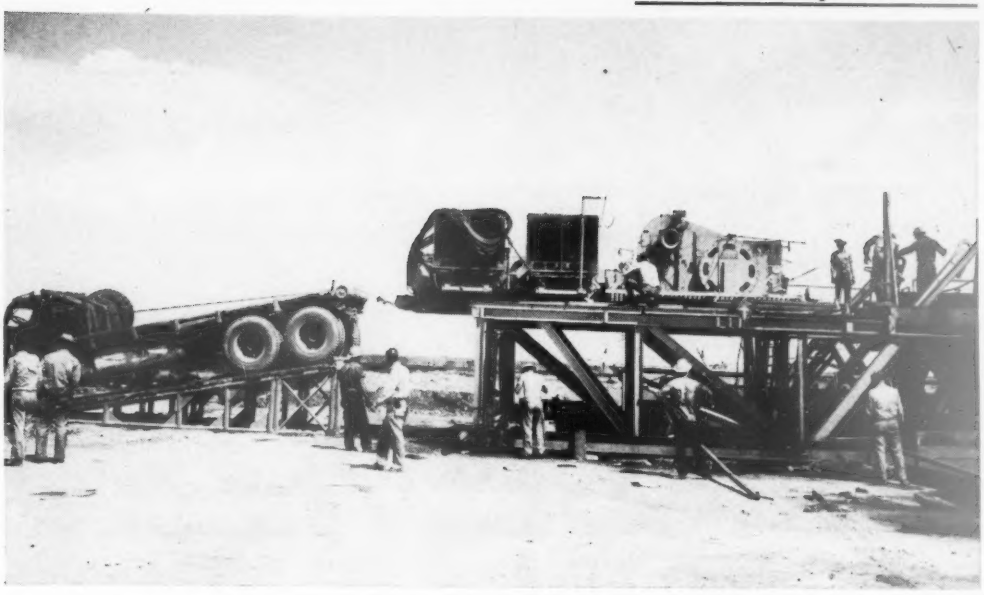
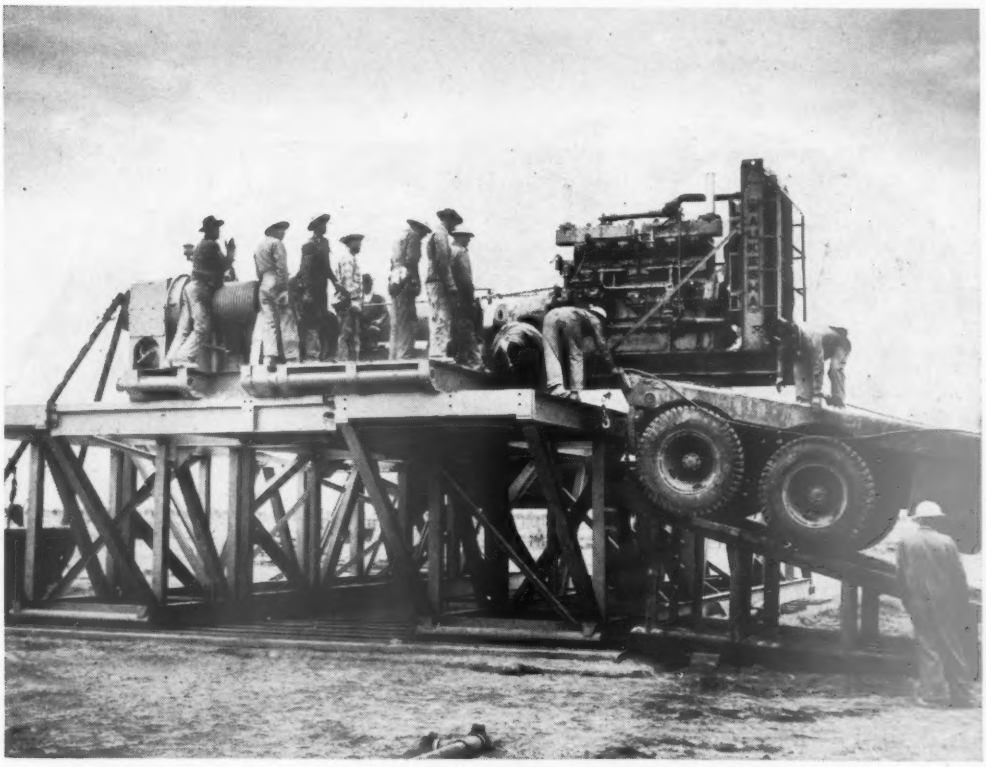
Wherever industry uses heavy duty clutches or power take-offs there is a ROCKFORD distributor conveniently close at hand to supply ROCKFORD Heavy Duty CLUTCHES, POWER TAKE-OFFS and replacement PARTS for numerous types and sizes of each.

IN THE OIL FIELD



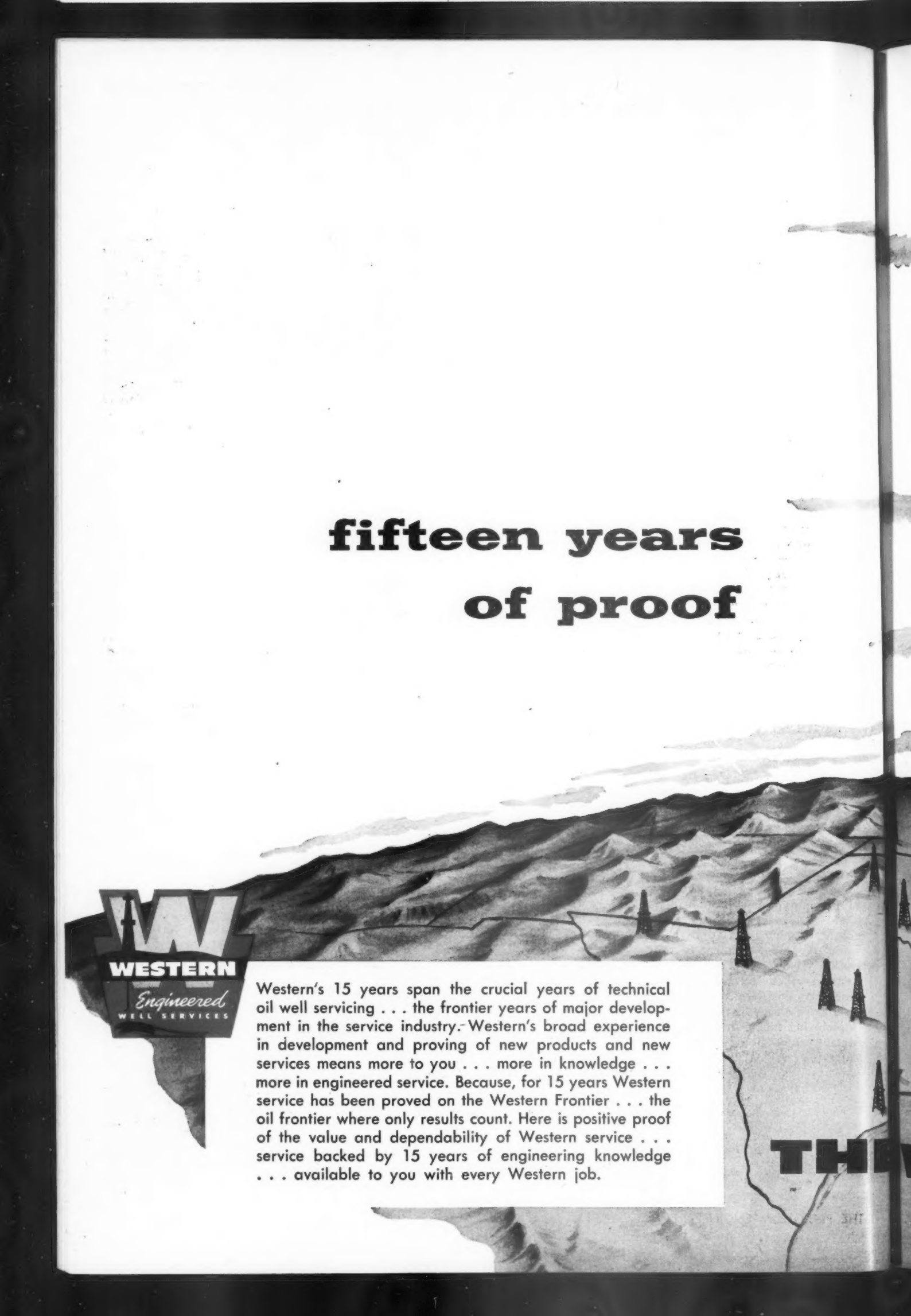
Tool pusher, usually principal coordinator in rig moving operations, must keep various elements of work in mind and vary crew assignments for most efficient work utilization. Winching drawworks off substructure to bed truck is example of operation that should be carefully planned.

Loading drawworks from ground to a flat bed truck is different type operation from above and requires different use of manpower. Effective utilization of manpower on such jobs releases men for other work, such as new site preparation, old site cleanup, stowing equipment in racks.



Removing engine preparatory to moving to new location. Twelve men are pictured around engine and drawworks. Not all of them can be working effectively. Reduction of as much "enforced idle time" as possible to crew members not actually engaged in removing engine should be first consideration given by supervisor.

fifteen years of proof



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• Development of first six-per-foot jet gun using standard jet charges with one prima cord. • Dolofrac! — the most advanced fracturizing solution in the field. • Significant developments in low surface tension and de-emulsifying agents for treating acid. • Adaptation of plating-out technique in radioactive tracer surveys to provide an accurate down-hole picture. • Use of internal breakers in fracturing gels and emulsions. • Pioneer development of "controlled" well treatments with packers • Two-way radios to provide faster, better service in the field. • Complimentary field engineering studies for "custom made" remedial well treatments. • 11,522' test well exclusively for development and proving of new products and techniques.

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ACTIVITY DATA SHEET

Operation TEAR DOWN - MOVE - RIG UP ROTARY RIG No. 20 Sheet No. 1 of 6 Sheets

Date: AUG 4, 1953

Operator: CREW #3 Observer:

Time Reading	Subtracted Time	Description of Activity
8:00		
8:10	10.0	DRILLER GET DIRECTIONS FROM TOOLPUSHER
		WHILE MEN WAIT.
8:30	20.0	TAKE CANVAS OFF ENGINE CANOPY
		AND FOLD. STORE IN DOG HOUSE
8:50	20.0	TAKE DOWN & ROLL UP LIGHT WIRES
		STORE IN DOG HOUSE. (1 MAN
		IDLE)
9:01	11.0	TAKE DOWN & ROLL UP LIGHT WIRES-
		STORE IN DOG HOUSE.
9:51	50.0	DISMANTLE MUD-LINE

FIG. 1. First step in improving methods is to describe and record operation being studied on a form such as "Activity Data Sheet," which shows the sequence of operation, time consumed, and describes operation. Example shown here was made during a rig moving operation.

and field personnel must have an understanding of the objective and the technique of methods improvement; second, management must realize that good, fair studies take weeks and months to complete (therefore, a hurry-up job may be a mistake); and third, the personnel performing the analysis must have a constructively questioning attitude, an unbiased mind, and have the confidence of both central management and field personnel.

Work is a dynamic thing consisting of a series of actions through a period of time. To properly observe and measure work, then, it is necessary to see, describe and record, and time the operation being studied. Methods may be improved by merely recording a description, in sequence, of the various elements of work being studied. Then, these elements are questioned as to their necessity, simplicity, and order. A better method is designed as a result of this analysis. If possible, though, the work should be timed. Only by knowing the time length of each of a series of actions can one tell the relative importance (from point of view of time) of these segments of the job.

Steps 1 and 2, that is, getting a picture of the present method and then putting the information obtained into a form that facilitates understanding, require thought and planning previous to embarking on the actual study. The objective of the study and the type personnel to whom the information will be presented must be considered. One recommended manner of accomplishing these first two steps is the use of an Activity Data Sheet. The elemental activities of one man, or several, are described and timed as they occur. Such a work sheet is shown in Fig. 1. Then, from this data, an activity chart is constructed by plotting the activities in proportion to time as in Fig. 2. This graphic representation of an operation then facilitates Step 3 of analysis and Step 4 of the design of an improved method.

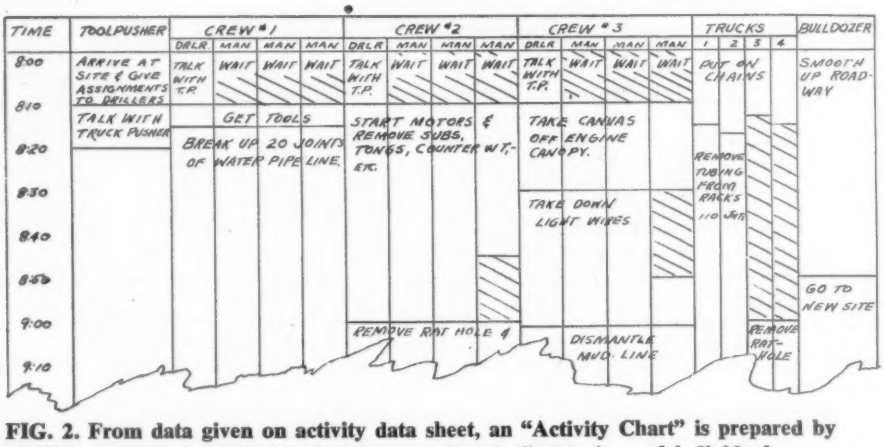
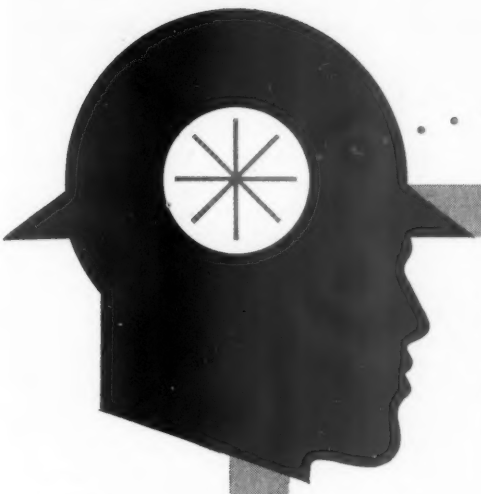


FIG. 2. From data given on activity data sheet, an "Activity Chart" is prepared by plotting activities in proportion to time consumed. Comparison of individual efforts to overall operation is made easier by this chart. From such a graphic presentation, analysis can be made and improved methods designed.

The information gained by investigations of the type described provides a solid basis for the analysis of many operating alternatives. For instance, one company now knows, to the nearest 1/1000 minute, the average time it takes to spin in and to spin out a joint of tubing. In addition, they know the average time to flip a spinning chain or rope. They know how long it takes to pull or set slips of any certain size. They have the figures on the average time it takes to latch and unlatch the tongs while making a trip. From these data, the economic desirability of installing power slips or power tongs can be more accurately determined.

After observing, recording, and timing numerous tripping operations, it has been conclusively proved that a fast "slam-bang" driller does not accomplish as much work as the smooth steady operation of the rig in pulling or running tubing. It was a surprise to learn, in contrast to what one's eye told was the best crew, that the smooth steady driller was making his trips in 15 per cent to 30 per cent less time. This saving in time is in addition to safer conditions and saving of equipment.

As a result of observations taken, it has been found that the time consumed at the mid-point of a trip (while the bit is out of the hole) may vary from 5 to 45 min. The question naturally arises, "Why this variation?" The reasons, of course, are many. For instance, time is taken to grease the rig. Then this operation should be constructively questioned. Is this the best time to do it? Is it done whether the rig needs it or not? If this is the time to do it, what should be greased? How is the best way to do it? Can the grease points be reached while drilling ahead? If not, can they be made so that this is possible? This type of questioning should be applied to every action of the crew. Some companies are finding it advisable to formulate



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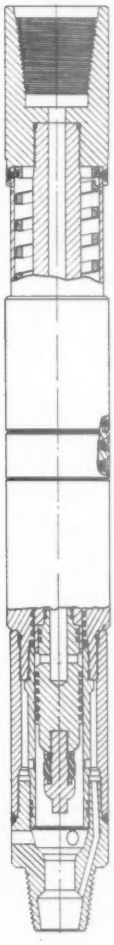

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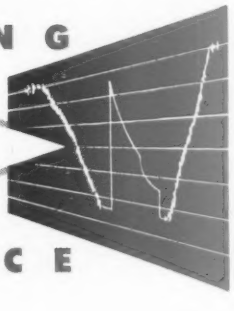

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a standard operating procedure to follow during this time interval between pulling tubing and running tubing.

A study of the activities of the crews assigned to a rig will very often bring to light certain practices which are known, but never questioned. For instance, the custom of a driller making only half a trip on his tour. Studies of many crews indicate that the bit usually needs changing when there is only time left (before the next tour starts) to bring the bit out of the hole. No predetermined stand should be taken on such a practice until all the facts are considered. But, the point is that the custom should be questioned and analyzed.

Utilization of the crew member's time is an important item, whether it be normal drilling operations or during the moving of portable rigs. More equitable distribution of the work load can result from an analysis of data obtained.

Study of the movement of portable rigs is a major investigation in itself. During a move, there are more men and equipment together at one time than at any other period. Supervisory problems are magnified and planning is most important. A study of the activities being carried out during a tear-down, move, and rig-up will provide the basis for a number of auxiliary analyses. For instance, do you know the cost of digging and boarding-up a cellar in man-hours and supplies? A complete 6 by 6 by 3 ft cellar was found to cost an average of $40 to $50 in labor and materials.

In studying the moving operations, it was found that the method shown in Figs. 1 and 2 was quite useful. The activity chart accurately pictures the entire field of operations. Utilization of the individual efforts of the crewmen were depicted. In addition, activities of the trucks and bulldozers can be studied and analyzed. Probably the most important aspect is provision for studying sequences in which jobs are performed. Did crews stop on job, begin another, and then return to the first? The shorter time a crew works at one activity the greater is the comparative percentage of time spent on getting ready and transferring to another activity. In one rig-moving study there were 11 drillers and roughnecks present. At no time were there more than 9 men productively employed. This was not an evidence of "goldbricking," but rather an indication that the supervisors should spend more time planning "what comes next" than lending a hand on the present activity of their crews.

The study of moving operations has indicated that a step-by-step description of the work to be done can be an aid to both drillers and tool pushers. It is an advantage to everyone concerned with moving a rig to have, not only a knowledge of one's specific duties, but also, a clear picture of the entire operation. The tool pusher is usually the principle coordinator during a move. The time necessary to accomplish the various elements of work will vary a great deal. He, then, must have the entire situation in mind, and be on the ground, so that he can vary the crew assignments according to the specific situation.

Job design is not management, but it is an important tool of good planning. It must be employed with care, by the right people, and with understanding by all concerned. The patient, intelligent search for facts will pay off in the long run. The knowledge and aid of field personnel is a necessity. They are the people who will install and make the changes work. It, therefore, is very important that roughnecks, drillers, tool pushers and drilling superintendents be continually consulted during the making of the study, the analysis, and the design of improved methods. It must be emphasized that methods study is not a "one-shot" activity, but rather, it must be a continuing search for the safest, easiest, simplest, and quickest way to do the job. * * *

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ROTATIVE GAS LIFT

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C. V. KIRKPATRICK*

THE number of rotative gas lift installations is steadily increasing for several reasons. First, high pressure gas is not always available. Second, a more rigid enforcement of the conservation statutes is evident. In certain areas of foreign production, where maximum gross liquid recovery is desired, naturally flowing wells can be stimulated to produce at much higher rates by gas lift principles. This results in greater liquid recovery with a reduced gas-oil-ratio (GOR).

In the States, the rotative gas lift system offers four distinct advantages. These are:

1. Greater liquid recovery with lower GOR's.
2. Higher allowable due to lower GOR's.
3. The operator can take advantage of nearby high pressure sales gas lines to pay out quickly the investment by sale of produced gas. If the gas is rich enough, the system can be supplemented with a custom-designed, all-skid-mounted, refrigeration-compression liquid recovery system that will materially speed up the pay-out period.
4. The economic life of wells going to water can be greatly extended by higher gross volumes of liquid recovery.

In considering the design of any rotative gas lift system, the total problem should always be emphasized. The total problem involves essentially five basic considerations. These are:

First, the gas requirements, both current and ultimate. It is to be emphasized that, in a rotative system, once the maximum requirement is fulfilled only nominal amounts of make-up gas are required to keep the system operative.

Second, the design of the injection and gathering lines. Consideration should be given to the provision of storage capacity in the injection system, and to additional wells that may be included at a later date.

Third, selection of the compressors based on the optimum injection pressure as determined from the gas requirement analysis. Compression ratios, capacity, compressor mounting, and the application of rotary blowers to increase in-take pressures, should be included here.

Fourth, the selection of gas lift equipment and equipment auxiliaries. This includes retrievable vs standard valves and mandrels, packers, standing valves, surface intermitting control equipment, and surface two-pen pressure recorders.

Fifth, consideration should be given to sales gas lines in the vicinity and to the possible incorporation of the custom designed refrigeration-compression liquid recovery system. If the produced gas is rich enough and is available in quantities as low as 1,000,000 std. cu ft per day, attractive pay-out benefits can be derived from this combination system.

A specific problem example will now be taken to illustrate the complete procedure for analysis. The example involves 9 wells, all currently flowing and having current producing characteristics as set out in Table 1. This problem represents an actual producing condition and will be analyzed in accordance with the 5 basic principles as listed above. An analysis for a second group of wells in the same field (10 wells) will be presented also, in order to show the effect of P.I., the size of gathering and discharge system, and various tubing well-head pressures upon the results of the analysis.

Gas Requirements and Injection Pressure

The production history of the wells revealed fairly consistent P.I.'s in spite of the fact that the bhp was beginning to decline fairly rapidly. The wells are all located downdip (near the water contact), and it is believed that this accounts for the relatively consistent P.I.'s. In recognition of this characteristic, it was decided that a continuous flow analysis, based on well P.I.'s of 0.5, 1.0, and 2.0, would be representative.

In order to present a conservative estimate (i.e. maximum gas requirements), the shut-in bhp was assumed at 2700 psig, (under current producing conditions it was estimated that this would be the bhp two years from date of the analysis), the solution GOR as 800 std cu ft per bbl, and the producing water-oil-ration (WOR) as 10:1. Note from Table 1, that the current maximum WOR is a little better than 1:1, but the WOR history has been one of a steady increase for the wells.

Using the above assumptions, a complete detailed analysis, using Phillips Gradient Charts for wellhead pressures of 40, 100, and 200 psig has been made.* The 200-psig wellhead system is preferred by the operator because of the extensive gathering system and certain sales gas commitments. (Fig. 13) The 100 and 40-psig systems are included for comparative analysis.

TABLE 1. Current well producing characteristics.

No.	Well No.	Gross prod desired B/D	Current % S.W. prod	Current P.I.
1.	1.	100	Trace	0.20
2.	2.	400	66.00	4.94
3.	3.	400	26.00	2.00
4.	4.	400	0.30	1.00
5.	5.	400	0.40	2.00
6.	6.	200	10.00	0.20
7.	7.	400	0.30	1.00
8.	8.	400	0.20	1.00
9.	9.	400	7.00	0.500

Tubing size = 2.0"—wellhead pressure desired = 200 psig
Current bhp = 2900 psig; current soln GOR = 1000 Ft³/bbl
Gravity of oil = 43 API; gas gravity = 0.70
All wells currently flowing against 200 psig at surface.
Well locations as shown in Fig. 1.

First, complete pressure gradient traverses (using the Phillips Gradient Curve for 2-in. tubing) were calculated for total fluid rates of 400, and 600 bbl per day, with a WOR of 10:1. These traverses are shown in Figs. 1-6. From these traverses curves showing injec-

Director, Department of Petroleum, University of Houston.

*For details of this procedure refer to *The Power of Gas* by C. V. Kirkpatrick, published by Cameo Inc., Houston, Texas.

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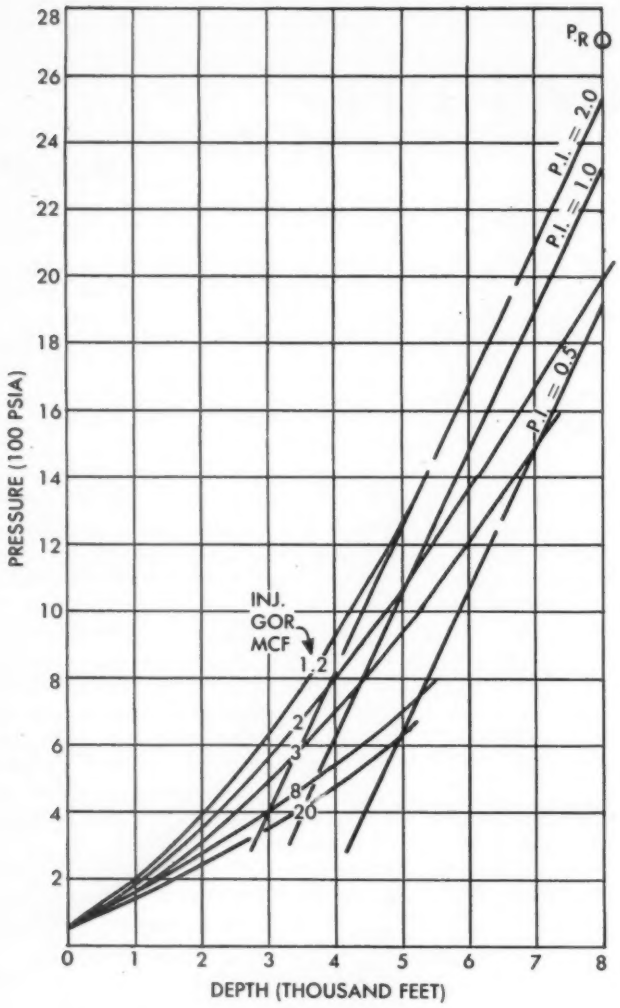

FIG. 1. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 400 B/D
P.I. — 2.0, 1.0, 0.50
Tubing pressure — 40 psig
WOR — 10:1 Tubing — 2″

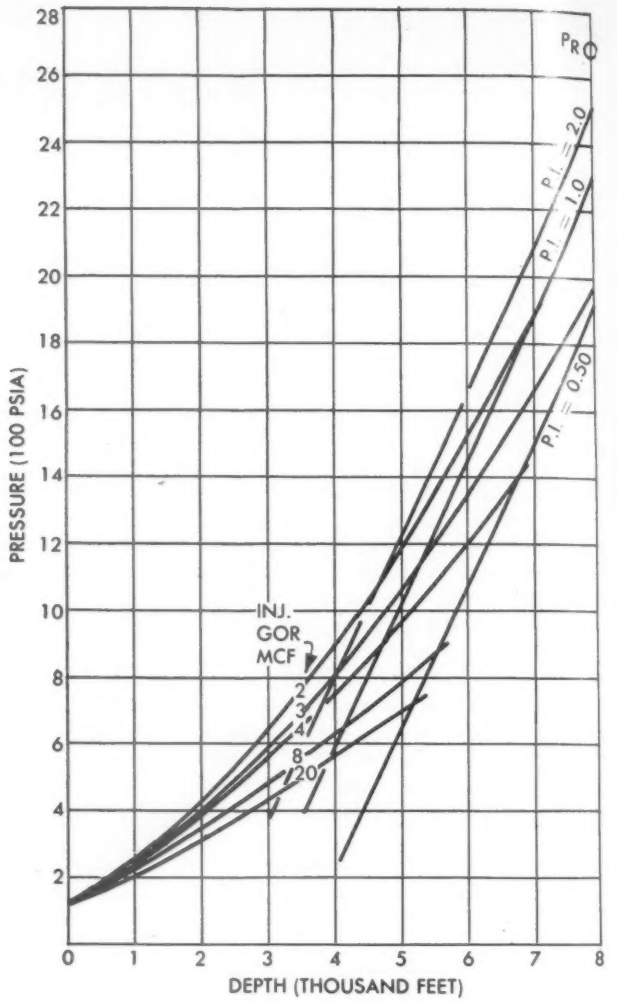

FIG. 2. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 400 B/D
P. I. — 2.0, 1.0, 0.50
Tubing pressure — 100 psig
WOR — 10:1 Tubing — 2″

tion GOR vs injection pressure for the different combinations of conditions were plotted. These data are shown in Figs. 7-10.

From the injection GOR and injection pressure, the ideal adiabatic horsepower has been calculated. In this calculation it is assumed that the gas is compressed from separator pressure (40, 100, 200 psig) to injection pressure (800 and 1000 psig). This ideal adiabatic horsepower is then plotted against the corresponding injection pressure. These curves for the 400 bbl per day rate are shown in Figs. 11-13.

From Fig. 11, it can be seen that the optimum injection pressure for the 200 psig separator condition is 1200 psia. An injection presure of 1000 psia is found to be within 10 per cent of the optimum, however, and was therefore selected because it is still within the efficient range. Also, it will be observed from Fig. 11, that for the 40 and 100-psig separator condition the 1000-psia injection pressure is very close to the optimum. This is a significant consideration for, as will be seen from the analysis of the second group of wells, a 100-psig wellhead pressure can be used, because of the reduced size of the gathering system.

Gas requirements by wells were estimated for injection pressures of 800 and 1000 psig. This procedure has been followed, in order to emphasize the effect of compression ratio and compressor capacity for the two sets of conditions. It will be noted from Fig. 11, that the 800-psig injection pressure is within the efficient range for wellhead pressures of 40 and 100 psig, but is in the inefficient range for the 200-psig surface pressure.

Fig. 10 shows the effect of well P.I. on gas requirements for a producing rate of 600 bbl per day. Note also from Figs. 11 and 12, that for wells with a P.I. of 2.0, the 1000 psi injection pressure is in a much more efficient range than for the wells with a P.I. of 1.0.

From these curves, together with the information in Table 1, maximum gas requirements per well have been estimated for the two injection pressures of 800 and 1000 psig. These gas requirements are presented in Table 2. It is pointed out, that when making the gas requirement estimate for the low P.I. wells, the injection pressure may indicate a prohibitively high injection GOR or may not intersect the curve at all. See Fig. 10 for injection pressure of 800 psi, P.I. of 1.0, and tubing pressure of 200 psig.

This does not necessarily mean that the producing rate is impossible under the existing conditions. In this case for continuous flow it is impossible, but when in the inefficient range for continuous flow, the indications are that for nominal producing rates the well can be more efficiently produced by intermittent flow.

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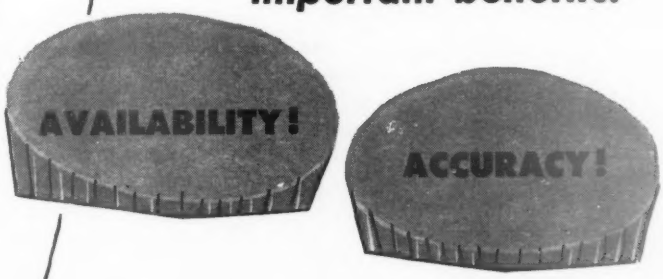

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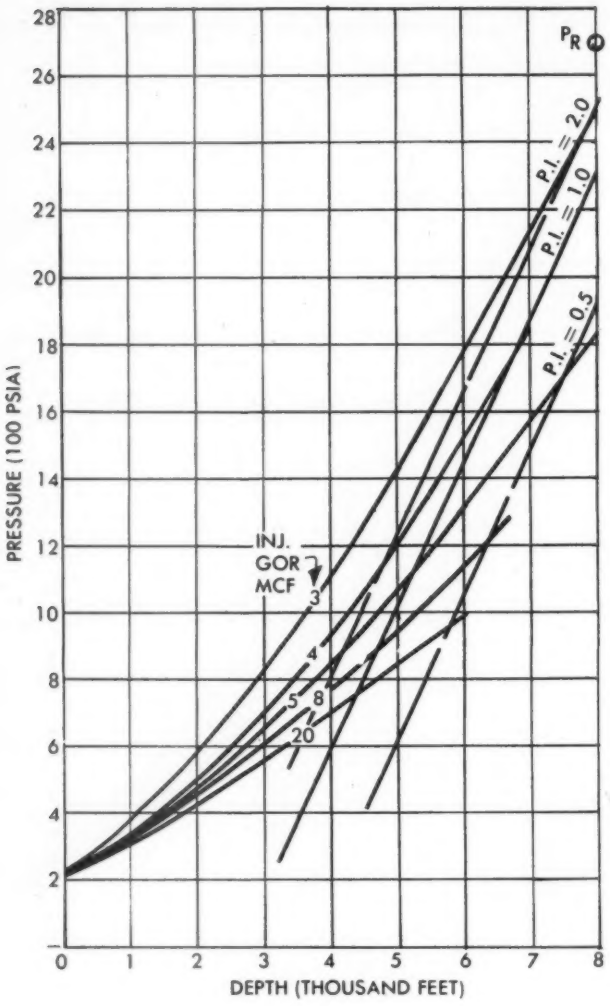

FIG. 3. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 400 B/D
P. I. — 2.0, 1.0, 0.5
Tubing pressure — 200 psig
WOR — 10:1 Tubing — 2"

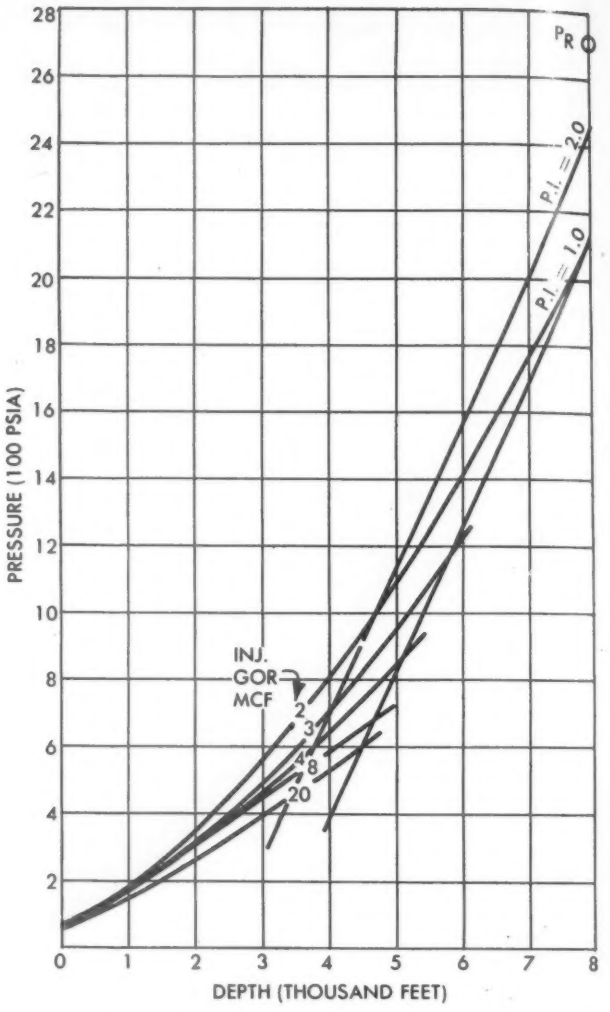

FIG. 4. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 600 B/D
P. I. — 2.0, 1.0
Tubing pressure — 40 psig
WOR — 10:1 Tubing — 2"

wells with the low P.I. (well numbers 1 and 6, P.I. = 0.2), the continuous flow estimate has simply been doubled. This is believed to be a reasonable approximation in view of the high bhp and low fluid requirements for these wells.

Design of Injection and Gathering Line

In the design of the injection line system, foremost consideration must be given to the maximum gas requirements and the incorporation of additional wells into the system. The network should be laid out with the view towards looping the lines, if additional capacity is needed at a later date.

Prior consideration for tying-in the "dead-ends" of the system should be given. This operation will serve to greatly increase the capacity of any system, but unfortunately, the field application has been given but little attention in the past. The trunk lines, taking the output discharge of the compressor, should be adequately sized so as to handle the maximum gas requirements.

Adequate storage must be available in the system. This is particularly true when the compressor is undersized and intermittent and continuous flow wells are fed from the same network. There is no set rule as to what this storage capacity should be in relation to the system as a whole. At the outset, however, if the compressor is capable of handling the maximum required volumes, and the line system has been properly sized, there will be ample storage in the system itself. As gas requirements increase, and they may

TABLE 2. Estimated gas requirements by wells.

				Injection GOR-MCF											
				40 psig separator		100 psig separator		200 psig separator		Total 40 psig separator		Gas 100 psig separator		MCFD 200 psig separator	
No.	Well No.	Gross fluid prod desired B/D	P.I.	800 psig inj.	1000 psig inj.	800 psig inj.	1000 psig inj.	800 psig inj.	1000 psig inj.	800 psig inj.	1000 psig inj.	800 psig inj.	1000 psig inj.	800 psig inj.	1000 psig inj.
1.	1.	100	0.20	2.80	2.20	4.80	3.45	11.70	6.00	102	80	175	126	426	218
2.	2.	400	4.94	1.00	1.00	1.50	1.20	3.00	2.20	36	36	55	44	109	80
3.	3.	400	2.00	1.90	1.55	3.10	2.30	6.15	4.40	69	56	113	84	224	160
4.	4.	400	1.00	2.80	2.20	4.80	3.45	11.70	6.00	102	80	175	126	426	218
5.	5.	400	2.00	1.90	1.55	3.10	2.30	6.15	4.40	69	56	113	84	224	160
6.	6.	200	0.20	2.80	2.20	4.80	3.45	11.70	6.00	102	80	175	126	426	218
7.	7.	400	1.00	2.80	2.20	4.80	3.45	11.70	6.00	102	80	175	126	426	218
8.	8.	400	1.00	2.80	2.20	4.80	3.45	11.70	6.00	102	80	175	126	426	218
9.	9.	400	0.50	6.80	4.50	12.00	6.10	15.00	15.00	248	164	436	222	572	572
								Total gas requirements-MFCD		932	712	1592	1064	3269	2062

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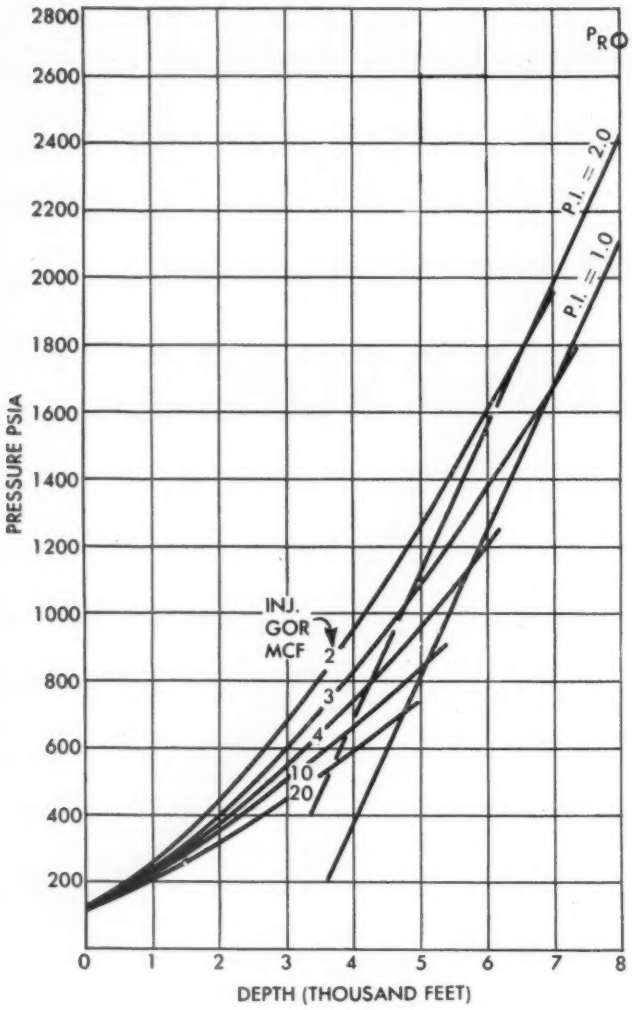

FIG. 5. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 600 B/D
P.I. — 2.0, 1.0
Tubing pressure — 100 psig
WOR 10:1 Tubing — 2"

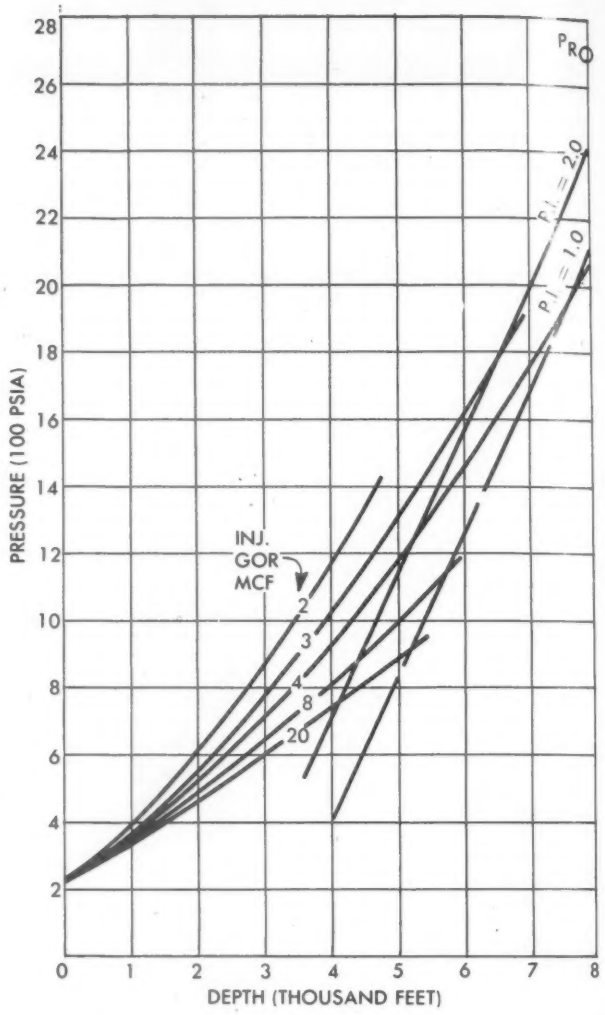

FIG. 6. Pressure vs depth for various well P.I.'s and injection GOR's.
Total fluid — 600 B/D
P.I. — 2.0, 1.0
Tubing pressure — 200 psig
WOR — 10:1 Tubing — 2"

eventually exceed the compressor capacity, the need for additional gas storage becomes critical.

It is suggested that storage space, that will take care of one-third to one-half the difference between compressor capacity and maximum gas requirement, with all wells kicking at once, will provide a satisfactory system. This additional capacity could be provided by an old abandoned well, the annulus of wells not on gas lift, or a shallow well with large diameter casing drilled specifically for the purpose.

Reference to Fig. 13 will show the solution to the injection and gathering system of this particular problem.

The first step in the solution is to list the maximum gas requirements opposite each well. The maximum gas requirements for the injection pressure of 1000 psig and a separator pressure of 200 psig has been listed opposite each well, except well No. 2. (Table 2). For well No. 2, the 800-psig injection and 200-psig separator pressure gas requirements have been used. This is about 40 per cent greater than the 1000-psig injection pressure and 200-psig separator requirement.

This larger gas estimate has been used because the well is now making 66 per cent water and may soon have to be produced at a much higher rate than the 400 bbl per day, in order to make the allowable. Although its P.I. is also high, approximately 5, it is anticipated that high gas requirements may be necessary to move high liquid volumes through the 2-in. tubing.

The second step is to show the length of each line segment on the sketch together with the maximum gas it will be required to deliver in MCFD. The maximum gas requirement figures are simply cumulative additions from each well as it passes a junction point, until the compressor is reached.

The third step is to size the lines at maximum capacity for negligible pressure drop. This can be conveniently accomplished by reference to a combination chart produced in the NGSMA (Natural Gasoline Supply Men's Association) Handbook. This chart is based on Weymouth's Formula and gives the pressure drop per mile of length for various sizes of pipe and various rates of flow. It is well to recall here, that Weymouth's Formula normally gives a pressure drop that is somewhat higher than actual and, hence lines sized by this chart will represent a conservative choice.

Fig. 13 shows a total length of injection line as follows: 2-in.—19,475 ft; 3-in.—5200 ft. The total cost per foot of the two sizes of pipe purchased, wrapped, and laid is $0.68 per ft for the 2-in. and $1.13 per ft for the 3-in. Therefore, the total cost of the system is $19,110.

It is to be noted, that this system is in a marshy area and the lines must be laid along the routes as shown in

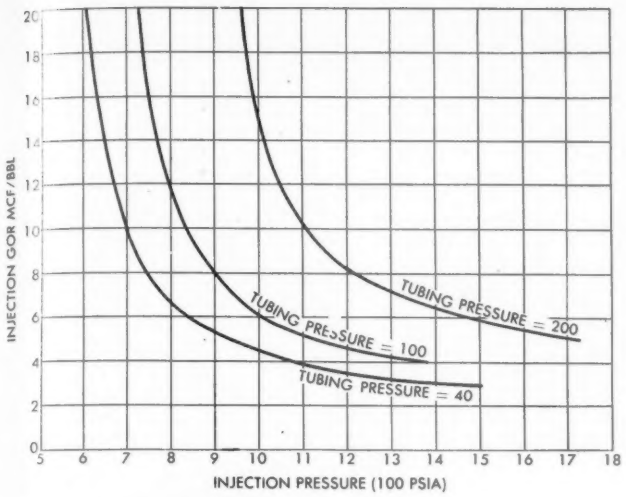

FIG. 7. Injection GOR vs injection pressure
Total fluid — 400 B/D
P.I. — 0.50
WOR — 10:1 Tubing — 2″

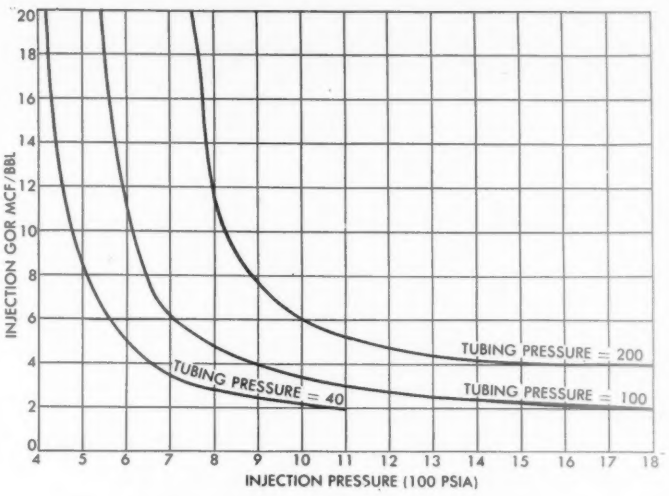

FIG. 8. Injection GOR vs injection pressure
Total fluid — 400 B/D — P.I. — 1.0
200 B/D — P.I. — 0.5
WOR — 10:1 Tubing — 2″

Fig. 13. It will be seen later that the discharge system for 10 other wells in the same reservoir costs only about one-third of this one, because the wells are much more closely grouped.

The gathering system can use the existing gathering lines, which run parallel to the injection lines shown. Some modification will be necessary in terms of looping the lines, in order to take care of peak capacity. It is pointed out that the 200-psig separator system must handle a higher volume of gas (injected plus solution) at a lower pressure than the injection line system. Hence the existing gathering lines will have to be looped when peak gas requirements become necessary.

In lieu of specific sizing data on the gathering lines, it is estimated that expenditures for modification of the gathering system will approximate 50 per cent of the injection line cost, or approximately $10,000. The gathering system will be handling from 300,000 to 1,000,000 cu ft per day more than the injection system. The oil allowable in this field is in excess of 100 bbl per day per well.

For 9 wells with a solution GOR of 1000 cu ft per bbl, the produced solution gas will, at the outset, approximate 1,000,000 cu ft per day. During the period of this high formation gas production, however, the injection gas requirements will be negligible because the wells will almost be making their allowable by natural flow. This gas can all go into the sales gas line, except for that amount needed for make-up in the injection system.

As the water production increases in each well, the produced solution gas will decrease until it approximates the estimated design conditions. That is, a total stock tank oil rate from the 9 wells of approximately 300 bbl per day (i.e. 3000 bbl per day total fluid with WOR 10:1). This then will represent a minimum formation gas production of approximately 300,000 cu ft per day that will be available for sales.

It is important to note that in this case, the gathering system will be at maximum capacity at the outset, if the 40 or 100-psig wellhead system should be selected, and hence should not be over designed. There are instances, of course, in which this will not be the case and should, therefore, be considered accordingly.

Advantages of this dual injection-gathering line system are emphasized.

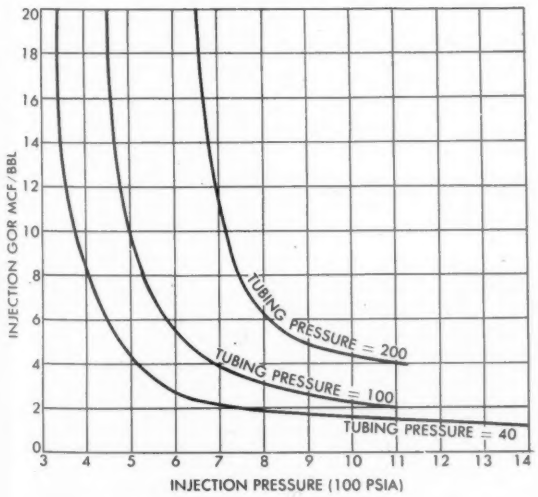

FIG. 9. Injection GOR vs injection pressure
Total fluid — 400 B/D
P.I. — 2.0
WOR — 10:1 Tubing — 2″

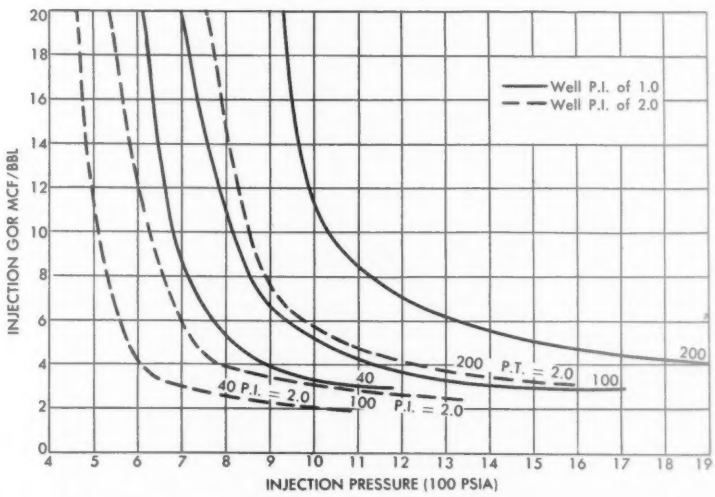

FIG. 10. Injection GOR vs injection pressure
Total fluid — 600 B/D
WOR — 10:1
Tubing — 2″

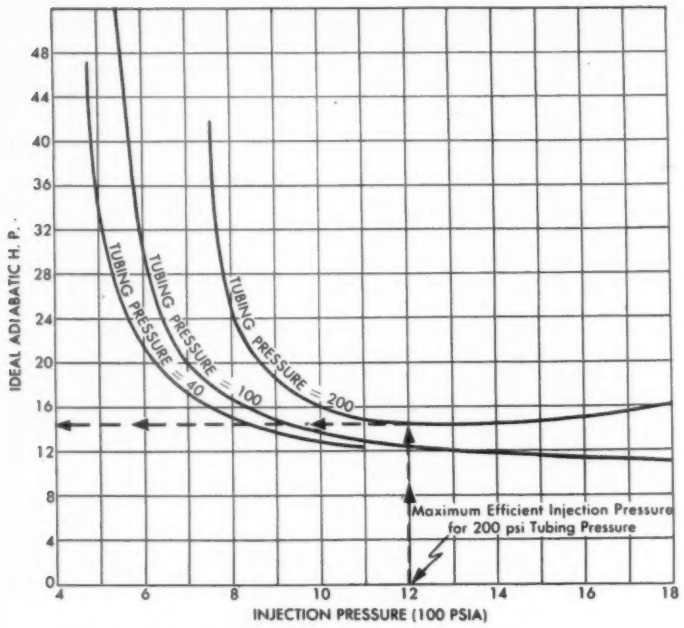
IDEAL ADIABATIC H. P.
INJECTION PRESSURE (100 PSIA)
TUBING PRESSURE = 40
TUBING PRESSURE = 100
TUBING PRESSURE = 200
Maximum Efficient Injection Pressure for 200 psi Tubing Pressure

FIG. 11. Ideal adiabatic H.P. vs injection pressure
Total fluid — 400 B/D — P.I. — 1.0
200 B/D — P.I. — 0.5
WOR — 10:1 Tubing — 2″

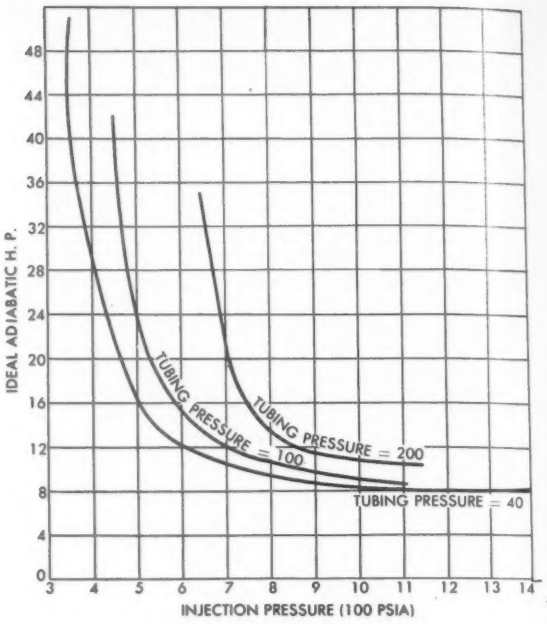

FIG. 12. Ideal adiabatic H.P. vs injection pressure
Total fluid — 400 B/D
P.I. — 2.0
WOR — 10:1 Tubing — 2″

No gas is wasted; all surplus gas over and above the injection requirements go into the sales line. Once the maximum injection gas requirement is placed in the system, then only nominal amounts of make-up gas will be required. This means that the wells can be carried to economic depletion with a fixed quantity of gas and that penalties normally incurred for high GOR wells will be minimized.

If a sales gas outlet is not immediately available, consideration should be given to returning the produced gas to the reservoir or to storing it in a shallow sand. It is again emphasized that this long range planning will result in excellent returns and that it can be instituted with but little increase in the initial investment, if considered at the outset of the design of the system. The existing reserve will, of course, determine whether or not gas storage or gas injection is feasible.

Compressor Selection

In selecting compressors for a rotative gas lift system, several factors must be considered. First, and perhaps foremost, is the factor of initial investment. It is to be noted that small capacity units are now available to the industry. A principal advantage of these units is that selection of full and final compressor capacity is not necessary at the beginning of the rotative system installation. This will serve to reduce the initial investment and may afford a more convenient method of budget allocation.

On the other hand, many operators prefer the larger self-contained compressor units, even though the initial cost is somewhat higher. The choice is usually dictated by company policy or personal preference. The important point is that the economics of compressor selection is now quite flexible and can be conveniently made for a variety of conditions. Emphasis is again placed on the total picture before final selection is made.

A second factor of considerable importance is the compression ratio. For optimum performance in multi-stage compression, it can be shown that the compression ratio for each stage should be constant and for most installations should not exceed 4:1. Compressors are now specifically designed for the higher compression ratio and, consequently will give satisfactory performance when operating in this higher range. The previous field concept has placed the maximum compression ratio around 2.5:1, and for the older compressors this was desirable.

An important point, insofar as the gas lift application is concerned, is in recognizing that compressor selection is a function of both compression ratio and capacity (i.e. horsepower). This consideration is clearly demonstrated in the problem example at hand, by comparing the 200-psig suction, 1000-psig discharge with the 40-psig suction and 1000-psig discharge. Many operators immediately will rule out the latter condition on sight, whereas the actual analysis will show that a more

TABLE 3. Tabulated summary of rotative gas lift analysis of two groups of wells in same reservoir 9-well system and 10-well system.

Well system—Depth = 8000 ft
Total fluid = take 3100 B/D

Compressor		Total injection cost[2]		Cost[2] gas lift equipment and auxiliaries per well	Cost injection system	Cost gathering system modifications	Cost	
Discharge psig	Suction psig	Gas MCFD	Compressor				Average per well	Total for 9-wells
800	40	932	$22,600.00	$3,130.00	$19,110.00	$10,000.00	$8,864.00	$80,000.00
800	100	1592	48,000.00				11,694.00	105,000.00
800	200	3269	54,000.00				12,364.00	111,200.00
1000	40	712	24,600.00				9,099.00	81,800.00
1000	100	1064	27,500.00				9,420.00	84,800.00
1000	200	2062	48,000.00				11,694.00	105,000.00

10-well system—Depth = 8000 ft
Total fluid take = 3000 B/D

Compressor		Total injection cost[1]		Cost[2] gas lift equipment and auxiliaries per well	Cost injection system	Cost gathering system modifications	Cost	
Discharge psig	Suction psig	Gas MCFD	Compressor				Average per well	Total for 10-wells
800	40	1250	$27,500.00	$3,130.00	$7,370.00	$3,600.00	$6,977.00	$69,770.00
800	100	2166	48,000.00				9,027.00	90,270.00
800	200	4233	60,000.00				10,227.00	102,227.00
1000	40	922	24,600.00				6,687.00	66,870.00
1000	100	1379	48,000.00				9,027.00	90,270.00
1000	200	2776	54,000.00				9,627.00	96,270.00

NOTES: 1. Includes complete cost of compressor, cooling system, and skid mounting.
2. Includes retrievable mandrels and valves (5 per well), racker, surface control equipment for one well, and two pen pressure recorder for each well. (optional)

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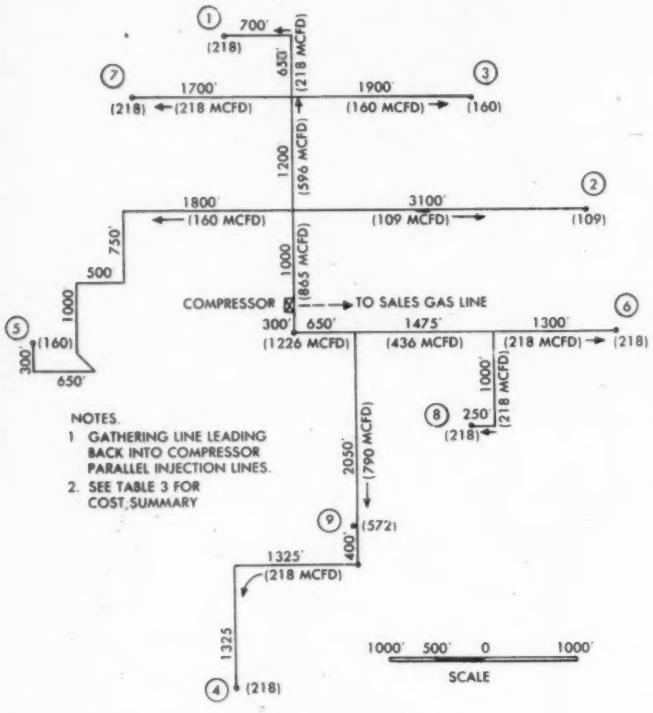

FIG. 13. Sketch showing the injection system for the 9-well group.

economical installation is possible with the 40-psig to 1000-psig condition.

The answer is in capacity. By allowing the gas to expand from the injection pressure of 1000 psig to a wellhead pressure of 40 psig, much more work is obtained than when it expands against the 200 psig wellhead pressure. The net result is that nearly three times as much gas is required for the 200-psig wellhead pressure as for the 40-psig. (Table 3) Therefore, if the smaller compressor units are being used, the 200-psig wellhead condition will require two units, whereas the 40-psig suction will require only one. This represents approximately a 60 per cent greater horsepower requirement. It is to be pointed out, that when considering compression ratios, absolute pressures must always be used.

As a further point in connection with the compression ratio of the two cases, it is clear that the 200-psig suction to 1000-psig discharge will take 2 stages, whereas the 40-psig suction to 1000-psig discharge would normally require 3 for a compression ratio of less than 4:1. When starting from low suction pressures, it is evident that the first multiple is the damaging one, insofar as stage requirements are concerned. Therefore, maximum effort should be made to keep the suction pressure as high as possible.

A third factor in compressor selection is that of mounting facilities. This is most commonly a nominal consideration, but can represent a sizeable investment in certain marshy areas. The smaller so-called "packaged type" compressors are conveniently skid mounted and require but little in the way of concrete foundation mounting. The larger units, of course, require a more elaborate foundation. The cost for these compressor platforms will vary from $1,000 to $10,000 depending upon the size and type of compressor and the geographical location.

In summary, the principal considerations in compressor selection are: Initial investment, which is often determined by the rate at which the wells are to be brought into the gas lift system; compression ratio and compressor capacity; maintenance of maximum intake or suction pressures; compressor mountings, and the over-all ultimate goal of the project.

Equipment and Auxiliaries

Selection of gas lift equipment and equipment auxiliaries is concerned principally with retrievable versus standard valves and mandrels, standing valves, packers, surface controlled intermitters, and two-pen pressure recorders. The retrievable gas lift mandrel with full opening tubing represents a significant gas lift equipment development. Although it represents a somewhat higher initial investment, its inherent advantages tend to offset the higher cost.

The elimination of work-over rigs in favor of wireline equipment to service gas lift valves and installations has advantages that are apparent to all concerned. The cost of the retrievable valve and mandrel currently is approximately $500. In this problem example, retrievable valves and mandrels have been selected on the basis of five per well. This amounts to a total cost of $2500 per well.

Employment of packers in connection with gas lift installations is highly desirable. Although not absolutely essential in all continuous flow installations, it is considered so in the intermittent ones. In continuous flow, the packer serves a two-fold purpose: First, it will maintain a steady bottomhole flowing pressure by protecting the face of the formation from pressure surges in the annulus, and second, it will prevent the gas from blowing around the tubing.

In intermittent installations, the packer is an almost essential requirement. First, it also prevents the annulus gas from blowing around the tubing. Second, it keeps the high gas pressure off the face of the formation. Third, it eliminates the necessity for unloading the well each time after production is shut down.

This is, of course, a very significant consideration, because the majority of intermittent wells must be unloaded with operating personnel present. The shortage of manpower in field operations is usually quite acute and hence elimination of repetitive unloading for various wells is most desirable.

A fourth and final advantage of the packer in intermittent well installations is that it, coupled with a standing valve in certain chamber type installations, makes the economic depletion of the well possible.

Cost of conventional packers is approximately $300 each. Considering 1 per well in the current problem example for 7 wells (as 2 already equipped) will give a total cost of $2100 for packers.

No standing valves are needed at the present time and none are therefore included in the cost estimate.

The surface control equipment consists simply of a regulator and possibly a choke for the continuous flow wells. As this equipment represents a very nominal expenditure and is usually available from stock, it has not been figured in the cost estimate of the continuous flow wells.

For the intermitting wells, of which there will be only one at the outset, the surface control equipment consists of a motor valve actuated by a time cycle controller. The cost of these units approximates $300.

Two-pen recorders for registering both the tubing and casing pressures are optional equipment but are highly recommended. These pressure recorders provide a graphic picture of the wells' performance and will ma-

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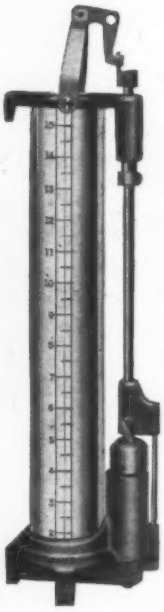

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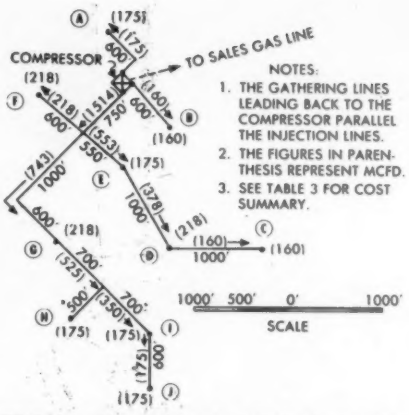
COMPRESSOR
TO SALES GAS LINE
NOTES:
1. THE GATHERING LINES LEADING BACK TO THE COMPRESSOR PARALLEL THE INJECTION LINES.
2. THE FIGURES IN PARENTHESIS REPRESENT MCFD.
3. SEE TABLE 3 FOR COST SUMMARY.
SCALE
1000' 500' 0' 1000'

FIG. 14. Sketch showing injection system for the 10-well group.

terially help the inevitable problem of trouble shooting. Their cost is approximately $300 each, and for 9 wells this would represent a total of $2700.

Table 3 shows the average total cost of gas lift equipment per well to be approximately $3130. The use of standard rather than retrievable gas lift equipment would reduce this total cost per well by about 40 per cent.

Extraction Units

As a final consideration in the rotative gas lift installation, the application of custom designed compression-refrigeration liquid extraction units should be determined. If the produced gas is rich enough (3 per cent pentanes plus), incorporation of a refrigeration unit may be warranted. These units show attractive payout periods for volumes as low as 1,000,000 cu ft per day, if the residue gas can be sold. For higher volumes and richer gas, the economics of the units are even more attractive. The 40-psig wellhead system is very desirable, if one of these units is to be included. The units are all skid mounted and can be moved from one location to another.

Many instances are of record in which the operator is passing valuable liquids on to the sales line when he himself could be recovering them for additional economic gain.

In order to determine the applicability of these units in conjunction with a rotative gas lift system, the following information is necessary:

1. Analysis of the gas.
2. Operating separator pressures.
3. Sales gas line pressure.
4. Volume of gas available.

The end products are a stabilized 18 psi Reed Vapor Pressure Natural Gasoline, LPG's, if desired, and dry sales gas. Again, it is emphasized that low separator pressures are most favorable for this operation.

Conclusion

The problem example as presented, represents an extreme case particularly because of the extensive gathering system. This fact notwithstanding, the economics are very definitely in favor of its installation. It is pointed out, that the total costs as listed, are not necessarily initial expenditures. The system can be programed and installed to conform with quarterly budget requirements.

For comparative purposes, and in order to emphasize certain significant points, any analysis covering a second group of wells in the same field (10 wells) has been made. The injection system for this second group of wells is shown in Fig. 14.

Table 3 gives a combined summary of the results of the analysis for the two groups of wells.

It will be specifically noted from Table 3, that the initial compressor cost is less for the 40-psig suction, 1000-800-psig discharge, than for the 200-psig, 1000-800-psig discharge. This is because the gas requirement in the case of the 200-psig suction is 3 times as great as for the 40-psig suction.

Cost of the injection lines for the 10-well system is only about ⅓ that of the 9-well system. (Compare Figs. 13 and 14.)

The higher gas requirements and lower total fluid take in the 10-well system are the result of characteristically lower well P.I.'s in this group as compared to the 9-well group.

The use of standard in lieu of retrievable type equipment would reduce the cost of gas lift equipment approximately 40 per cent. * * *

Texas-Sized Sandstorm?

Carroll G. McDowell, Carter geologist, who sat on Carter's Stonington wildcat in Colorado, has a vivid story about a dust storm that swept the rig.

Drilling crews pride themselves on keeping that bit boring into the earth in all kinds of weather.

But they had to shut down the Stonington rig for 72 hours during one of the "black blizzards". The dust became so thick that the driller no longer could see the indicator which told him how much weight he had on the bit. And a weight indicator has a face and dial almost as big as a grandfather clock.

For 24 hours the dust was so thick the crew was marooned at the rig and the crew for the next tour couldn't get out from town. The remainder of the down time was taken up in cleaning out the motors.

When the storm was over the slush pit, 140 ft long and 12 ft deep, was filled level with the surface with powder-fine dust.

McDowell, tidying up his 8 by 15 dog house after the storm, tossed out four buckets of dust.

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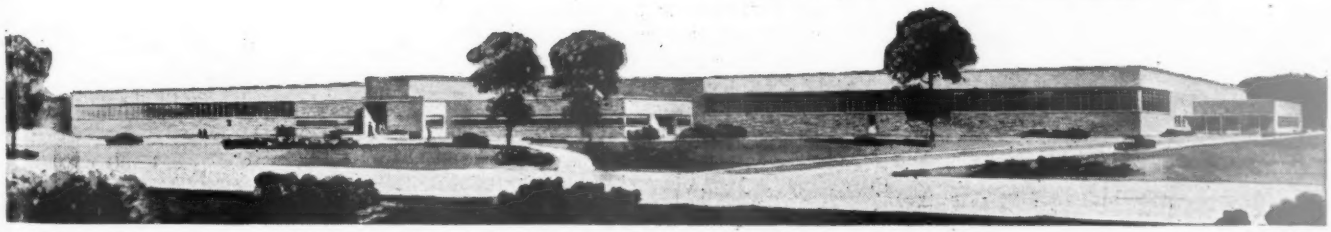

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Determination of

Effective Formation Permeabilities and Operation Efficiencies

of Water Input Wells

Surface performance data will indicate injection well operational efficiency and probable improvement from shooting, acidizing, or fracturing

JOHN C. JOERS and R. V. SMITH

USEFUL knowledge of formation and well characteristics has been derived by the analysis of pressure-buildup and pressure-decline curves from oil-production wells. As similar information about water-input wells is equally useful in operating water-flooding and pressure-maintenance projects, the pressure-buildup method of testing oil wells has been studied to determine its applicability to testing input wells. This study shows that the published equations that describe the pressure-buildup behavior of oil-production wells may be used, with a few additional assumptions, to determine qualitatively teh efficiency of input-well operation and the effective permeability of producing formations to water.

The operation efficiency of a water-input well, described as the ability of the well to take water at a given pressure, depends both upon the permeability of the formation in the vicinity of the well and the average permeability of the formation. For example, if the permeability of the reservoir rock immediately around the well bore is less than the average permeability of the formation, the large attendant pressure drop, known as the skin effect, results in low operation efficiency of the well. A zone or reduced permeability near an input well requires a higher pressure and consequently greater operation costs to inject water at a given rate into the formation.

The pressure-decline method for testing water-input wells described in this article permits evaluation of the pressure drop in that part of the formation near the well bore that has been damaged by the completion of the well or by subsequent injection of water. Damage by injection water could result from deposition of suspended matter, the precipitation of solids as a result of chemical reaction, or the swelling of clays.

This article presents a brief of the pressure-buildup analysis, a discussion of its applicability to water-input wells, and an analysis of several pressure-decline curves recorded during field tests.

The Authors

J. C. Joers R. V. Smith

John C. Joers is a reservoir engineer for Continental Oil Company at Ponca City, Oklahoma. A graduate of the University of Oklahoma with BS and MS degrees in petroleum engineering, Joers previously worked on secondary recovery problems at the U. S. Bureau of Mines Petroleum Experiment Station at Bartlesville, Oklahoma. Joers joined Continental in August 1954.

R. V. Smith is technical advisor to the chief production engineer of Phillips Petroleum Company's natural gas department. He was formerly with the Bureau of Mines and was engaged in research on natural gas and petroleum production problems. Smith is a graduate of the University of Missouri.

Pressure-Buildup Analysis

Several investigators[1,2,3,4,5] have presented methods of analyzing pressure-buildup data from oil wells. The following equation, given by van Everdingen and Hurst,[4] describes the relationship between the rate of change of the bottom-hole pressure in a well, after the well has been shut-in, and the fluid and formation characteristics, the well radius, and production rate before shut-in, for a reservoir with a constant permeability from the well bore to the radius of drainage.

EXCLUSIVE

$$P_\delta - P_f = \frac{\mu q}{4\pi KH}\left[\ln_\delta + 1n\frac{K}{\mu f c r_w^2} + 0.809\right] \quad \ldots\ldots\ldots\ldots (1)$$

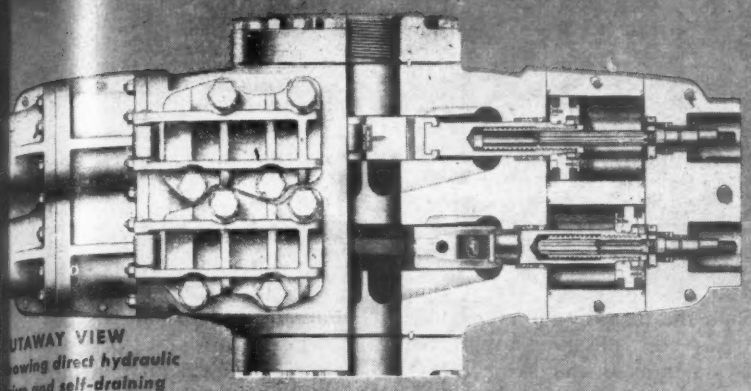
Where:

P_δ = pressure in the well bore at time δ, atm;
P_f = stabilized flowing pressure, atm;
q = production rate at reservoir conditions, cc. per sec;
μ = viscosity of the oil, centipoises;
K = effective permeability of the formation to the flowing fluid, millidarcys;
H = net effective thickness of the formation, cm;
δ = any time after shut-in of the well, sec;
f = porosity of the formation, a fraction;
c = compressibility of the formation liquid, volume per volume per atm;
r_w = radius of the well bore, cm

A plot of bottom-hole pressure versus the logarithm of time after a well is shut-in yields a curve with a straight-line section after a shut-in time ranging from a few minutes to several hours. The initial part of the curve, leading up to the straight-line section, represents a lag in pressure buildup. Its duration depends upon several factors, including the liquid compressibility, the formation permeability, and the volume of the well casing and tubing available for storage of the flowing fluid.

The expression $\frac{\mu q}{4\pi KH}$ from equation 1 represents the slope of the straight-line section of the pressure-buildup curve. After being converted to engineering units, as noted below, the slope of the curve may be expressed as follows:

$$m = 0.163\,\frac{\mu QF}{Kh} \quad \ldots\ldots (2)$$



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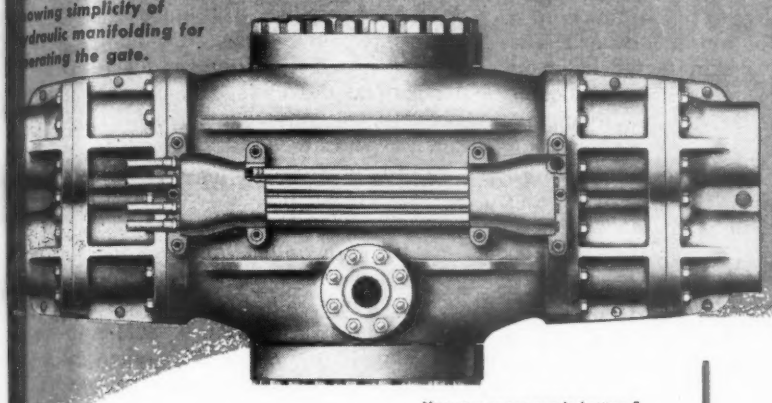

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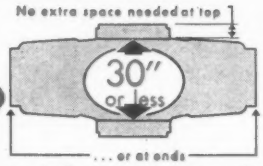

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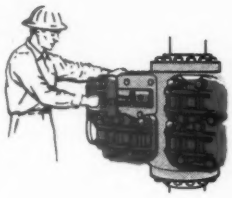

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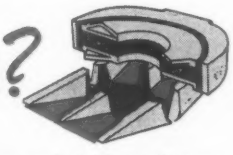

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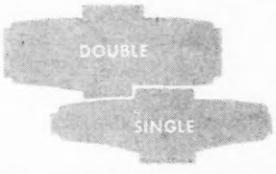

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Where:

m = slope of the straight-line section of the pressure-buildup curve, psi per $\log_{10}$ cycle;
Q = production rate, bbl of stock-tank oil per day;
F = formation volumes factor, vol per vol. (converts stock-tank oil volume to reservoir oil volume);
h = net effective thickness of the producing formation, feet.

Other symbols are the same as given before. The slope of the curve can be determined by measurement. As values for μ, Q, F, and h are known or can be estimated, the permeability may be calculated from equation 2. The calculated effective permeabilities, when compared with permeability values obtained by other means, as from core analyses and productivity indices, have been useful in evaluating well completions.[6,7,8,9,10]

Effective permeability values calculated from pressure-buildup curves are particularly useful because they represent the actual effective permeability to the flowing liquid of the producing formation away from the well bore to the boundary of the drainage area. If a permeability value indicated by a productivity index for a given well is lower than that indicated by an analysis of a pressure-buildup curve, the well evidently has been damaged by completion or production methods.

Van Everdingen [8] and Hurst[11] have extended the analysis to explain the deviation of observed pressure-buildup behavior from that expected by consideration of known fluid and formation characteristics. They introduced the concept of a skin effect and have shown that it is proportional to the additional pressure drop caused by a zone of reduced permeability near a well bore. The following relationship, given by van Everdingen, is a modification of equation 1; it accounts for the skin effect, S, which is dimensionless.

$$P_\delta - P_f = \frac{\mu q}{4\pi KH} \left[1n\,\delta + 1n\frac{K}{\pi f c r_w^2} + 0.809 + 2S\right] \quad . . . . . (3)$$

Where m is the measured value of the slope of the straight-line section of a pressure-buildup curve in psi per $\log_{10}$ cycle, equation 3 may be stated as follows:

$$P_\delta - P_f = \frac{m}{16.924} \left[\tfrac{1}{2}\,1n\,\delta + \tfrac{1}{2}\,1n\frac{K}{\mu f c r_w^2} + 0.404 + S\right] \quad . . . . . (4)$$

The viscosity and compressibility of the fluid can be determined; the production rate before the well was shut-in can be measured; and the well radius is known. If known values for formation characteristics including thickness, porosity, and permeability determined from the slope of the buildup curve are used, a value for skin factor S can be determined.

The concept of a skin effect was evolved to explain the excessive pressure drop that has been observed at many wells. Evaluation of the skin effect has been useful in providing an index of the effect of well-completion methods on well performance. If a formation has been partly plugged with mud during drilling or completion, a large skin factor will be indicated. The magnitude of a skin factor indicates the necessity of well treatments such as shooting, acidizing, formation fracturing, and reperforating. A comparison of the values of a skin factor before and after well treatment shows the effectiveness of the treatment.

Water-Input Wells

In general, similar techniques are useful in evaluating the performance of both oil-production and water-input wells.[12] Injectivity indices, for example, which are comparable to productivity indices of producing wells, have been used extensively to indicate the water-intake capacity of input wells. Also, pressure-buildup and pressure-decline curves have been useful in the analysis of both systems, although only qualitatively when applied to input wells. Similar equations might be expected to describe the behavior of both types of wells because the pressure-distribution curves of the two wells are mirror images, each being defined by the radial-flow equation.

For a detailed development of the statement there is a basis for similar analysis of input-well and out-put well behavior, the reader is referred to the section of van Everdingen's paper entitled "Analysis of Buildup Curves." The injection rate of an input well must be considered as a negative production rate, —q, and a superposed positive rate, q, is considered to account for shutting-in a well and the consequent zero rate of fluid entry into the formation. Van Everdingen's mathematical development then can be followed step by step, and equation 3, which he derived, can be considered applicable to water-input wells. All pressure-decline slopes are negative, as are values of injection rate and the quantity $P_\delta - P_f$.

In van Everdingen's development a single-phase, compressible fluid under nonsteady-state flow conditions is considered. Other considerations are necessary for equations 2 and 4 to be applicable to water-input wells. For the pressure-decline curve to reflect the permeability of the formation to water, enough water must have been injected before the test to insure that the pressure drop as reflected in the measurements will occur entirely in the water phase. Moreover, the liquid saturation of the formation should be high enough to preclude the possibility of a continuous gas phase. If liquid and gas are flowing simultaneously, equations describing two-phase flow must be used in the analyses. They have been discussed by Miller, Dyes, and Hutchinson.[2]

Until the pore space of a reservoir has been effectively filled with liquid, the intake rate of a well, under a constant injection pressure, declines continuously as the pressured radius is extended. Such a change in intake rate could be interpreted incorrectly from analysis of pressure-decline curves as a decreasing formation permeability.

Aside from the skin effect, another factor causing a deviation between observed and theoretical pressure-buildup behavior in oil wells is the storage capacity of the well casing and tubing. This factor is a function of fluid compressibility as well as the storage capacity of the well for the flowing fluid. Because the compressibility of water is much less than that of oil-gas mixtures, the effect will be less significant in the behavior of water-input wells than in the behavior of oil-production wells. However, fluid compressibility partly explains the observed differences in the relationship between pressure and the logarithm of time in the initial part of a pressure-decline curve.

In calculating permeabilities and skin factors for input wells, values for most of the terms of equations 2 and 4 can be measured or estimated readily. Values for two of the terms, liquid compressibility and well radius, may be difficult to obtain, however. The compressibility value of distilled water, at the estimated temperature of the formation, was used for results reported in this paper.

The dissolved-gas content of injected water, which would influence its compressibility, is low; and calculated values of skin factor are relatively insensitive to changes in liquid compressibility, as the two are related logarithmically. Actually, the compressibility of the residual oil also should be considered, giving a complete compressibility of the system, as shown by Miller, Dyes, and Hutchinson.[10]

Water-input wells are treated commonly by shooting and acidizing and less commonly by applying pressure to cause fracturing of the formation to increase their intake capacity. Although these treatments do enlarge the bore hole, this increase is not the most significant effect. A 6-in. hole would have to be enlarged to approximately

15 ft to double the intake rate, other conditions remaining the same.

The formation and extension of fractures in the vicinity of a well is the direct cause of an increased intake capacity, and the increase can be accounted for by considering an increased effective radius for the well bore.

An estimated value for the effective radius may be used in the calculations, but for comparative purposes the skin factor may be based on the original diameter of the well bore, as well as the diameter indicated by a caliper log. Whichever method is used in the calculations to determine the value for the radius of the well bore, the skin factor will be an index of the completion or operation efficiency of the well. As van Everdingen has pointed out, the actual value of the skin factor is questionable because its determination depends upon an accurate value for the radius of the well bore. The concept of the skin effect, however, is still very useful in explaining the intake characteristics of water-input wells.

A positive skin factor is defined as a dimensionless quantity that is proportional to the additional pressure drop at a production well or as the additional pressure buildup at an input well, caused by a zone of reduced permeability immediately surrounding the well. If no permeability restriction exists, the skin factor is zero.

A negative factor, implying a lower than normal pressure drop or buildup at a well indicates a zone around the well having a permeability greater than the average permeability of the formation. Well treatments such as shooting and acidizing increase the formation permeability near the well bore and probably explain the negative skin factors indicated for nearly all of the water-input wells treated.

A permeability restriction around an input well and the consequent positive skin factor indicated by a well test may be the result of any of the following actions: Precipitation from the injection water of suspended matter; a reaction between injection water and connate water; the injection of water that is chemically unstable, and the injection of oil or emulsion. An accumulation of paraffin or asphalt in the sand around oil-production wells and oxidation products in old air-injection wells may restrict flow if such wells are recompleted as water-input wells.

As the skin factor is directly proportional to that part of the pressure buildup in an input well that is caused by a zone near the well having a permeability different from the average permeability of the formations, it is a measure of the efficiency of a water-input well. A significant pressure drop occurs at wells exhibiting large positive

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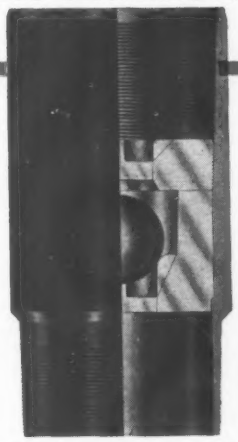

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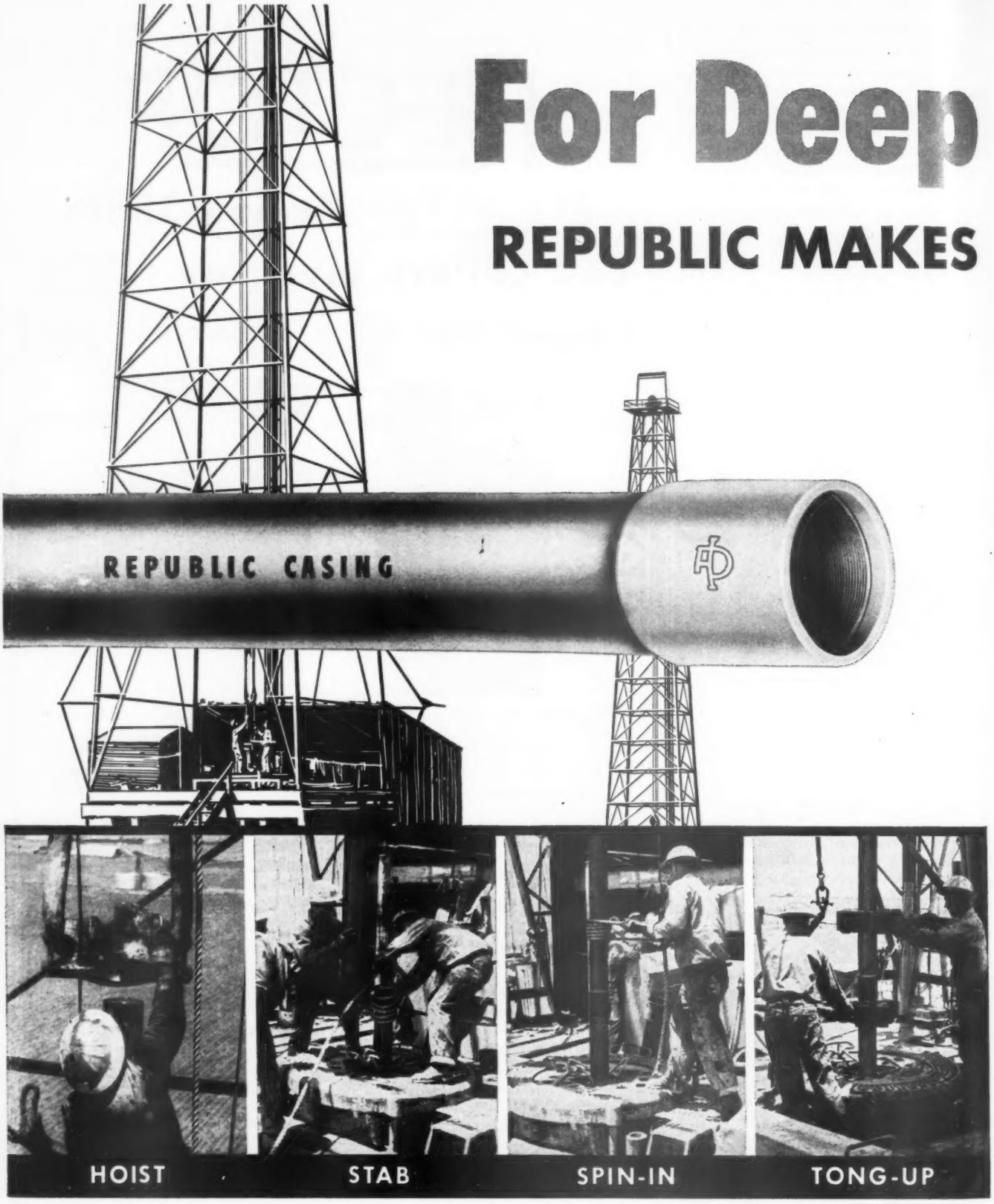

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skin factors. This pressure drop usually can be reduced by remedial work.

The larger the value of skin factor indicated, the greater the improvement that is likely to result from the remedial treatment. If a negative skin factor is indicated, the necessity for treatment is not so apparent, but improvement of the well by treatment is not precluded. Retreatment of wells and further reduction of skin factors have indicated additional improvement. Both the cost of well treatment and the expected gain from an increase in the intake capacity of the well must be considered to determine the limit to which it is desirable to improve well performance by additional treatments.

Changes in the magnitude of the pressure drop attributable to the skin effect afford a more useful comparison of well performance before and after treatment than do skin factors alone. Van Everdingen has shown that the part of the total pressure drop at a production well (or pressure buildup at an input well) attributable to the skin effect is equal to $\frac{m\,S}{16.924}$, where m is the slope of the straight-line section of the pressure-log time curve, S is the skin factor, and 16.924 is a constant that allows the slope value to be expressed in units of psi per $\log_{10}$ cycle.

He points out also that values of effective well radius and formation permeability may be different for successive well tests, and, therefore, values of pressure expressed by $\frac{m}{16.924}$ $(\frac{1}{2}\ 1n\frac{K}{\mu f c r_w^2} + S)$ provide a better comparison in evaluating well treatments. Calculated values of $\frac{m}{16.924}$ $(\frac{1}{2}\ 1n\frac{K}{\mu f c r_w^2} + S)$ are proportional to the injection rate. For a true comparison the value indicated by a test after well treatment should be multiplied by the factor Q_1/Q_2, where Q_1 is the input rate before treatment and Q_2 is the rate after treatment.

The initial part of a pressure-decline curve reflects the skin effect, either positive or negative, and the effect of the storage capacity of the tubing, this part of the curve therefore does not exhibit the straight-line relationship. The straight-line plot usually is established after a relatively short shut-in time, and the value of its slope is essential to the calculation of permeability values and skin factors.

Equation 2 shows that, for a given input rate, the decline-curve slope is inversely proportional to the formation permeability. In a highly permeable formation the buildup of pressure near an input well is small, and after the well has been shut-in, the slope value of the decline curve is small. Conversely, in a formation with low permeability, both the pressure buildup and the slope valve are large.

The selection of a specific part of a pressure-decline curve to be used in calculating permeability values and skin factors was not difficult for the well tests described in this report. However, conditions causing an irregular pressure decline at an input well, such as interference through a direct channel from a producing well, could make the selection of a straight-line section of the curve difficult. A curve from a well shut-in for an extended time should reflect the effect of operating surrounding production wells, but this effect should not be noticeable during the few hours necessary to obtain a straight-line relationship between pressure and logarithm of time after the input well is shut in.

For all wells tested a straight line was established after an average time of 90 minutes, and no significant changes in slope occurred after that for shut-in times of as long as 24 hours.

Pressure-buildup curves from oil wells have a characteristic S-shape, and curves from water-input wells were expected to be shaped similarly. Of the 35 pressure-decline curves reported in this article, plus an additional 15 curves recorded later, only 5 exhibited that characteristic shape, however. Those 5 curves assumed the S-shape after less than 2 hours' of shut-in time; some of the remaining curves represented shut-in times of 24 hours or more. Particular well conditions reflected by negative skin factors were assumed to account for the type of curves recorded. After a study of all the recorded curves, the ones accompanying this report were chosen as representative pressure-decline curves.

Test Procedure

The test procedure is simple and easy to carry out; one person can test several wells in a day. Because of variations in the density of liquids in a production well, bottom-hole pressure measurements are required to obtain a pressure buildup curve. For a test of a water-input well, however, wellhead-pressure measurements are used. They are obtained from a pressure-recording gage, which is connected to the wellhead with copper tubing.

The well-input pressure should be constant for several days before the test to insure stabilized conditions. After the input rate has been measured, the well is shut off at the wellhead and the pressure-decline curve is recorded. Tests should be made only after operations in the vicinity of the test well have been stable for a few days. If wells offsetting the intended test well have been shut down, the test should be delayed.

To be useful, the recorded curve must have a straight-line section. For most wells tested that condition was established after approximately 2 hours, and all wells tested showed the relationship in less than 3 hours. A few points of the decline curve can be plotted on semilogarithmic paper during the test so that the shut-in time of the well can be limited to the time necessary to establish a straight line. After the test, as the well is being opened, presssure-rate measurements can be made to permit the determination of an injectivity index.

Results of Field Tests

Pressure-decline curves have been recorded for 35 water-input wells in 5 different production areas of northeastern Oklahoma and eastern Kansas. One of the wells was retested after a few weeks, and 5 other wells were retested 9 months after the original test on each. The second tests were made to obtain comparative data on skin effects and permeability values after remedial work was done on the wells. A few other wells were tested, but reliable data were not obtained because faulty valves prevented the complete shut-off of injection water during the test.

Daily injection rates, wellhead-injection pressures, and net effective-sand thicknesses for each of the 41 well tests are given in Table 1. Also included in the table are the slope values of the pressure-decline curves and the calculated skin factors and permeability values.

The results of 5 pressure-decline tests are shown graphically in Figs. 1 through 5; data pertaining to them are given in Table 1. The first 4 of the 5 tests were made on 2 wells in Osage County, Oklahoma, which for this discussion are identified as wells A13 and A15, before and after remedial work done to eliminate or reduce the loss of water through a badly channeled section. The fifth test was made on a well in Anderson County, Kansas.

Well A13. From the data obtained in the initial test on well A13, the wellhead pressure in pounds per square inch versus the elapsed time in minutes after the well was shut-in has been plotted on semilogarithmic paper in Fig. 1. The slope of the curve is —126 psi per cycle. The effective permeability to water of the producing formation has been calculated from equation 2, assuming a value of 0.6 centipoise for the viscosity of the injected water at reservoir conditions, as follows:

$$K = 0.163\frac{\mu\,Q\,F}{m\,n},$$

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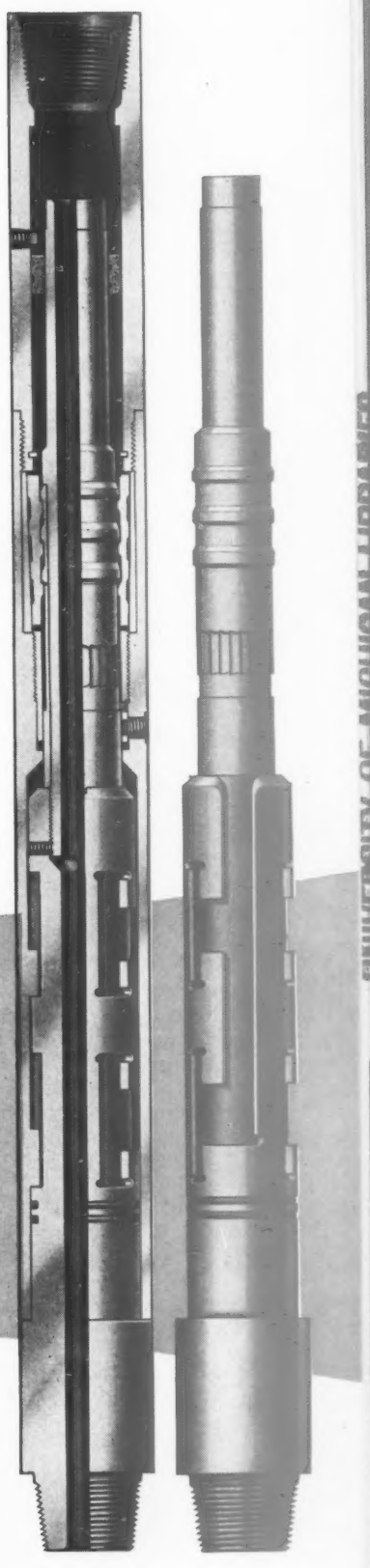

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orque free operation eliminates any aggravating tend- cy to release fishing tools, reduces equipment wear, nd avoids hazards.

ecause the tripping mechanism is purely mechanical, eavy blows can be struck despite packing failures or gh temperatures and the same heavy blows will be livered regardless of whether the string is elevated wly or rapidly.

e tripping pull can be increased while the tool is in e hole or the tripping pull can be either increased decreased while the complete tool or just the Bowl sembly is at the surface.

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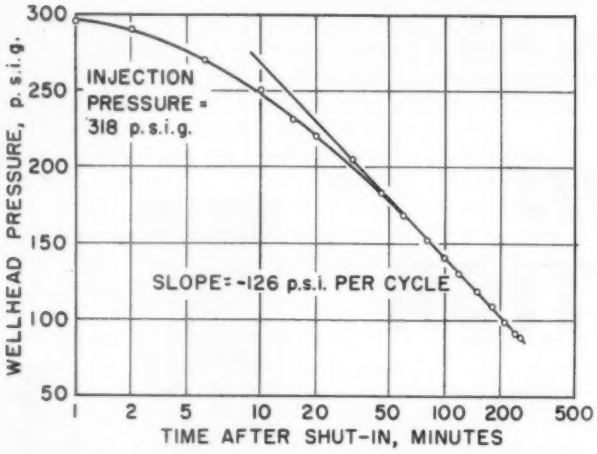


FIG. 1. Pressure-decline curve from well A13 before cementing.

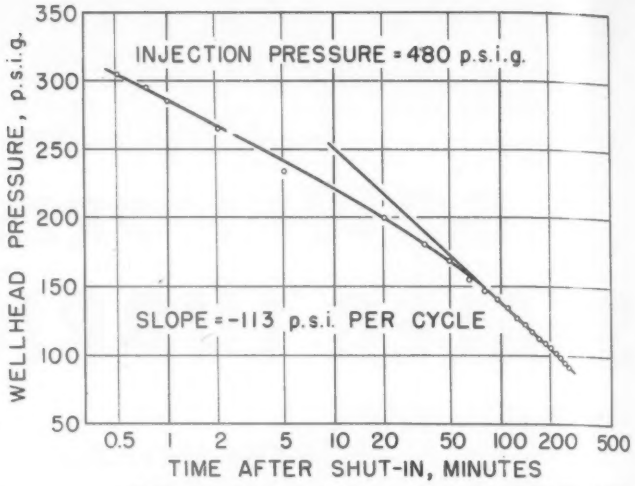


FIG. 2. Pressure-decline curve from Well A13 after cementing.

TABLE 1. Data used for calculating effective-permeability values and skin factors of wells A13, A15, and B-4.

	Well No. A13		Well No. A15		Well No. B-4
Test No.	1	2	1	2	1
Pf, atm	21.6	32.6	39.7	42.5	36.5
P_δ, atm	7.8	6.9	25.8	26.9	29.2
Q, bbl per 24 hr	1426	588	1349	136	62
μ, centipoises	0.6	0.6	0.6	0.6	1
k, millidarcys	0.023	0.010	0.034	0.0066	0.029
δ, seconds	9600	12,600	15,000	13,200	12,000
rw, cm	6.35	6.35	6.35	6.35	8.9
h, ft	49	49	38	38	25
c, vol per vol per atm	4.8×10^{-5}	4.8×10^{-5}	4.8×10^{-5}	4.8×10^{-5}	4.8×10^{-5}
f, fraction	0.16	0.16	0.16	0.16	0.18
m, psi per cycle	−126	−113	−104	−53	−14
F, vol per vol	1	1	1	1	1
S, dimensionless	−5.5	−3.3	−5.6	−2.0	+1.6

$$K = 0.163\,\frac{0.6\,(-1.426)}{-126\,(49)},$$

$$K = 23 \text{ millidarcys}$$

The formation volume factor was assumed to be 1.0 for all applications to water-input wells because the low dissolved-gas content of the injected water would result in little difference between the water volume at atmospheric pressure and at reservoir pressure.

The skin factor of well A13 was obtained by substituting data from Table 2 in equation 4.

$$P_\delta - P_f = \frac{m}{16.924}\left[\tfrac{1}{2}\ln\delta + \tfrac{1}{2}\ln\frac{K}{\mu f c r_w^2} + 0.404 + S\right],$$

$$7.8 - 21.6 = \frac{(-126)}{16.924}\left[\tfrac{1}{2}\ln 9600 + \tfrac{1}{2}\ln\frac{0.023}{0.6(0.16)\,4.8\times10^{-5}\,(6.35)^2} + 0.404 + S\right],$$

$$S = -5.5$$

The negative value of the skin factor indicates either that the permeability of the formation near the well is greater than the average formation permeability or that the effective radius of the well is larger (as a result of shooting or acidizing) than the radius of the bore hole. This well had been in operation for about 16 months when it was first tested; a cumulative volume of approximately 380,000 bbl of water had been injected. The well was shot during completion and was acidized later.

These treatments alone could account for the negative skin factors, but there is another contributing factor. Evidence provided by input-profile measurements and temperature logs indicated that the excessive water-intake rate of this well and several others in the area resulted from water loss through a fractured shale overlying the productive sand.

A few months after the first decline curve was recorded, several feet of the upper section of the open hole of well A13 was squeeze-cemented to seal the fractures and thereby effect a more efficient drive by the injected water. A second decline curve recorded 2

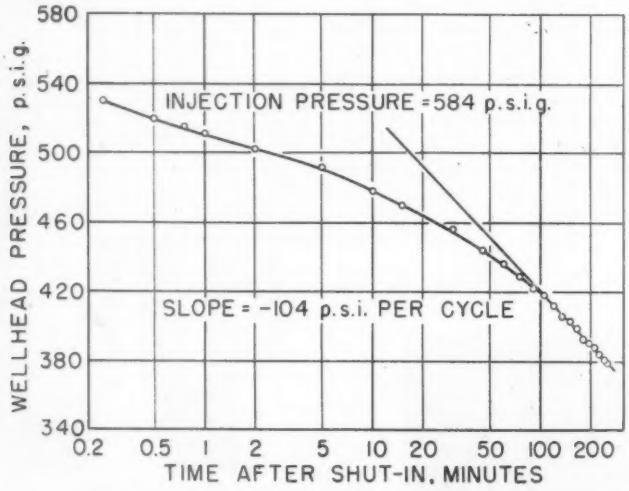


FIG. 3. Pressure-decline curve from well A15 before cementing.

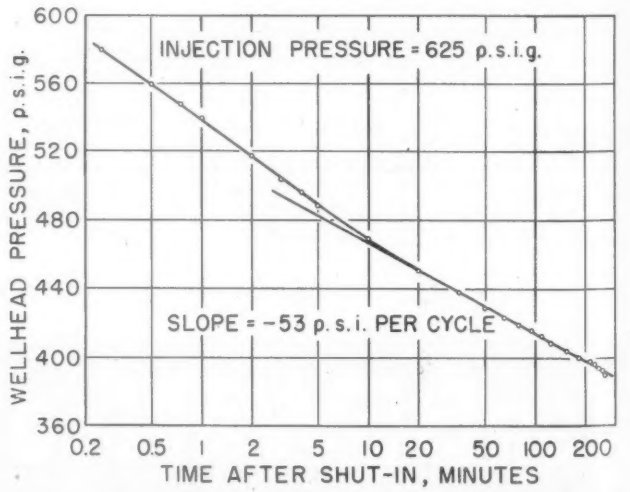


FIG. 4. Pressure-decline curve from Well A15 after cementing.

months after cementing was completed is shown in Fig. 2. A significant change in performance resulted from the well treatment, as is indicated by the reduced intake capacity of the well. The slope of the pressure-decline curve decreased slightly.

A comparison of the slopes of the curves alone, however, does not provide an adequate index of the effect of the remedial work, as the slope of the curve is proportional to the injection rate before the well was shut-in. The rate of injection before the well was shut-in must be divided by the slope to obtain a significant comparison. If water is injected into a well at a constant rate, after the sand body is filled with liquid, the slopes of succeeding pressure-decline curves from the well should be less, reflecting the increase with time of the effective permeability of the formation to water.

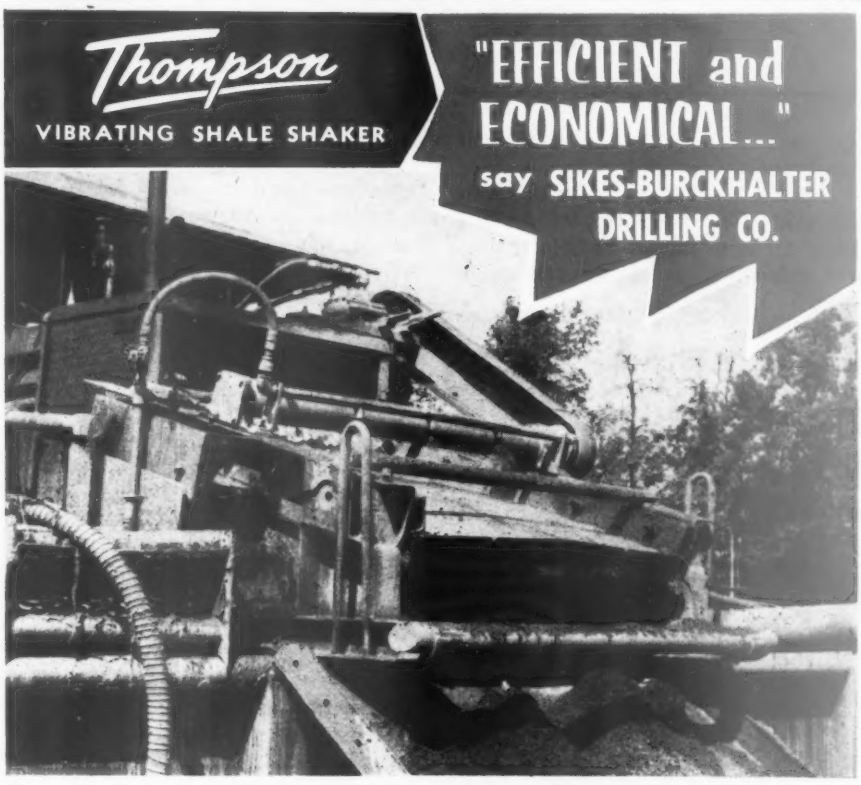
An average permeability of 10 millidarcys for the formation was indicated by the second test on well A13. The treatment of a well should not affect significantly the average permeability of the formation so it must be concluded that the reduction of permeability from 23 to 10 millidarcys was a result of the closing of extensive fractures. Cementing the upper section of the sand effectively reduced the value of h, the sand thickness. Because the h values were different for successive tests, a comparison of permeability-capacity values, the product of k and h, indicate more accurately the effectiveness of the well treatment. Before cementing, the permeability-capacity of the well was 1128 millidarcys per foot; after cementing, it was 490 millidarcys per foot. The well treatment effected a reduction in the initial intake capacity of the well of 56.5 per cent.

The change in value of the skin factor from —5.5 to —3.3 though slight when the reliability of the data is considered, is evidence of an increased pressure drop near the well such as would result from the elimination of a zone of high-intake capacity. Determining the actual value of increased pressure necessary to inject water into this well at the same rate after the cementing operation as before would be difficult because so many factors were changed. The net effective thickness of the formation, the effective radius of the well, and the average formation permeability were reduced as a result of the well treatment.

Well A15. Before the upper pay section in this well was squeeze-cemented, 1349 bbl of water was being injected daily at 584 psi well-head pressure. After treatment, the input rate was 136 bbl per day at a pressure of 625 psi. The initial calculated permeability capacity was 1292 millidarcys per foot, and after the squeeze-cementing job, it was 253 millidarcys per foot. Again, this great change in the injection rate can be explained by considering that the fracture system in the overlying shale was effectively closed off from the well by the cementing process.

The negative skin factor after treatment shows that the permeability of the sand near the well was still higher than the average permeability of the formation, but the decrease in absolute value of the skin effect is an index of the effectiveness of the cementing job.

Well B-4. Results of tests on well B-4 are shown to illustrate a positive skin effect. This well was shot when it was completed as a production well about 30 years ago and was shot again in 1953 when it was converted to a water-input well. The calculated effective permeability of the formation is 29 millidarcys, and the skin factor is +1.6. The positive skin factor indicates either that the recent shot was not completely effective in breaking through a permeability restriction near the well or that the sand face was plugged after water injection was begun. The absolute value of the skin factor is small, so further well treatment could not be expected to increase



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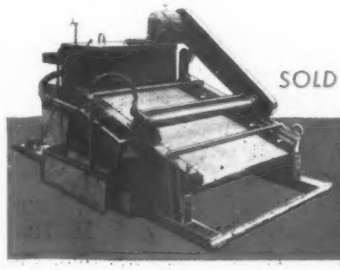

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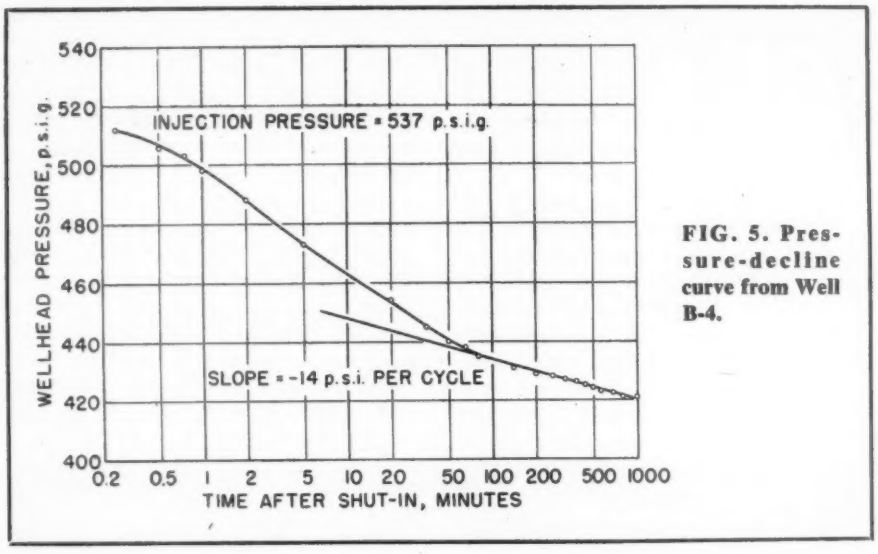

FIG. 5. Pressure-decline curve from Well B-4.

the intake capacity of this well significantly.

A pressure drop, caused by the positive skin effect, of 1.32 atm or 19.5 psi, at an input rate of 62 bbl per day, was calculated using the expression $\left(\frac{m\,S}{16.924}\right)$. If the skin factor were reduced to zero by additional well treatment, the injection pressure for the same input rate would be lowered 19.5 psi. Of course, additional well treatment could further increase the intake capacity of this well, and the treatment would be indicated by negative skin factors.

TABLE 2.—Effective-permeability values and skin factors from pressure-decline curves.

Well no.	Input rate, bbl per 24 hr	Wellhead input pressure, psi	Formation thickness, ft	Pressure-decline curve slope, psi per cycle	Calculated: Permeability, md.	Calculated: Skin factor
Project A. Burbank sand, Osage County, Oklahoma						
1	1318	336	33	—151	26	—5.8
2	1074	532	37	—32	88	—4.1
3	567	355	30	—81	23	—6.3
4	1260	488	30	—113	36	—5.8
5	1062	206	33	—32	98	—6.3
6	586	520	52	—35	31	—4.1
7	472	481	48	—31	31	—5.6
8	214	594	40	—80	6.5	—6.2
9	360	625	46	—40	19	—4.2
10	852	598	51	—34	48	—6.3
11	656	543	55	—43	27	—5.6
12	1332	453	64	—114	18	—5.8
13	1426	318	49	—126	23	—5.5
14	1520	328	38	—41	95	—4.7
15	1349	584	38	—104	33	—5.6
16	1142	500	36	—119	26	—6.1
17	2040	350	17	—132	89	—6.1
18	634	512	32	—71	27	—3.1
19	372	320	32	—54	21	—4.3
20	815	560	40	—100	20	—5.3
21	1440	488	42	—162	20	—6.2
22	451	600	24	—33	56	—1.1
Project A. retests						
13	588	470	49	—113	10	—3.3
14	431	593	38	—36	31	—0.30
15	136	625	38	—53	6.6	—2.0
17	1575	288	17	—161	56	—6.6
18	533	488	32	—41	40	+3.4
19	331	254	32	—56	18	—2.1
Project B. Squirrel sa		Anderson County, Kansas				
1	128	620	½	—36	21	—3.7
2	76	560	38	—5	65	+4.5
3	57	562	35	—49	5.4	—4.8
4	62	537	25	—14	29	+1.6
Project C. Bartlesville sand, Rogers County, Oklahoma						
1	124	390	26	—46	17	—4.3
Project D. Bartlesville sand, Washington County, Oklahoma						
1	411	820	41	—165	8.9	—4.8
2	488	750	46	—155	10	—4.3
3	348	725	28	—44	41	—4.8
4	303	720	22	—42	48	—6.0
5	191	600	28	—43	23	—5.5
Project E. Bartlesville sand, Nowata County, Oklahoma						
1	21	436	40	—57	1.5	—1.6
2	4.5	416	41	—26	0.69	+3.4
3	7.9	438	41	—72	0.44	—1.6

Conclusions

The pressure-buildup analysis has been shown to be applicable, with a few additional assumptions, to water-input wells. Skin factors and values of effective formation permeability have been calculated. They are useful in describing the operation efficiency of input wells in terms of pressure required for injection caused by zones of either higher or lower than average permeability near the well bore. Results from a single well test indicate, by the magnitude of the skin factor, whether the intake capacity of a well is satisfactory. If it is not, the possible improvement by acidizing, shooting, or fracturing can be estimated. The analysis is particularly useful in evaluating the effects of well workovers.

The analysis of data from periodic well tests reveals changes in intake performance. Gradual plugging of a sandface by impurities in the injected water is apparent as values of the skin factor increase. Conversely, loss of the injected water through fractured zones near a well, are indicated by decreasing values of the skin factor. Values of the effective formation permeability, after fillup, should increase gradually, reflecting the increased water saturation of the formation.

Acknowledgments

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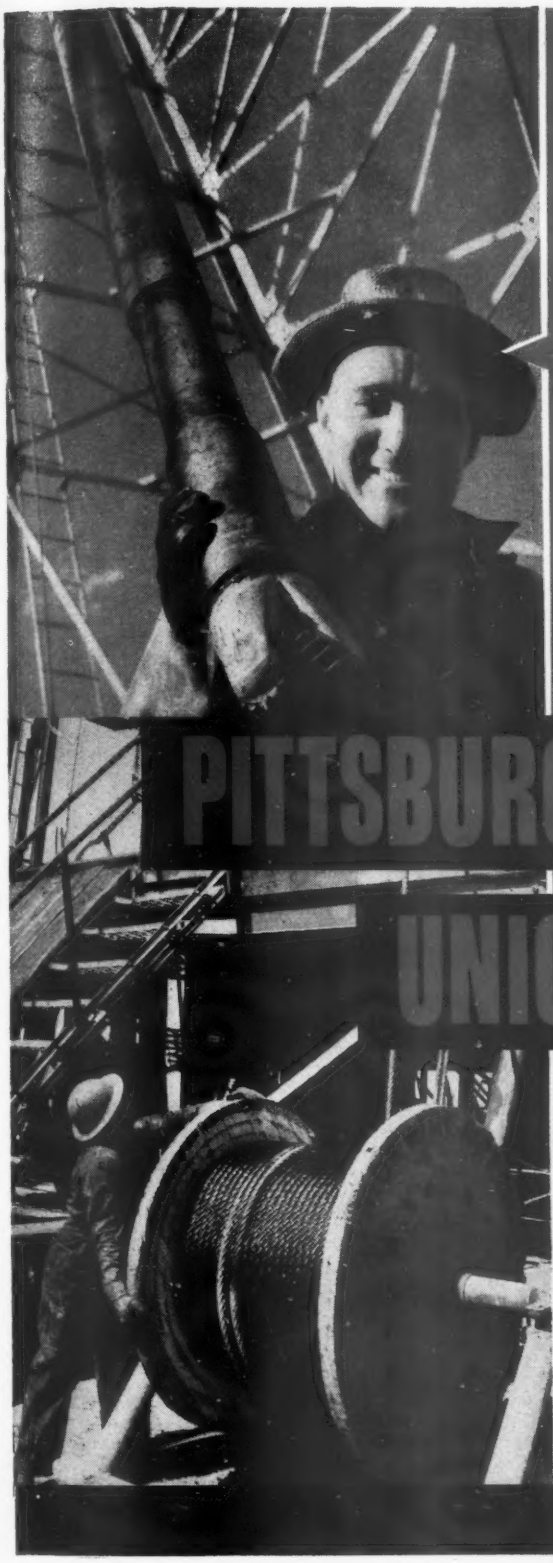

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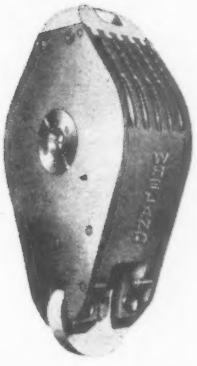

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Reservoir Performance of the Dominguez Seventh Zone Townlot Pool†

F. R. WADE

Abstract

The Dominguez Seventh Zone Townlot pool provides performance data which permits a reasonably accurate comparison between oil recovery under depletion control and recovery by active water drive. Although the pool is small, the unique nature of its history is considered to be of sufficient interest to provide substance for this paper.

THE Dominguez oil field is one of the large anticlinal structures lying along the Newport-Inglewood line of faulting. The field has been an important source of high quality oil in the Los Angeles Basin since its discovery in 1923 and has produced nearly 200,000,000 bbl of oil from 8 Lower Pliocene and Upper Miocene zones in 4 major fault blocks. The productive sands in all zones at Dominguez are of the blanket type characterized by a high degree of lateral continuity. Each of the 8 zones is comprised of a large number of individual sand bodies varying in thickness from 1 to over 40 ft.

The Seventh Zone Townlot pool, subject of this discussion, is noteworthy because of the unique nature of its production history. Lying at the extreme west end of the Dominguez structure, the Seventh Zone Townlot pool was, in its early stages of development, indistinguishable from the large adjacent Miocene (7th and 8th zone) West Block pool. (Fig. 1)

Development

First well completed in what subsequently became the Townlot area was Union Oil Company Austin No. 7, which was completed in March, 1941, in the Upper Seventh Zone. Following the completion of Hiles Drilling Corporation Grant No. 1 for 1300 bbl per day from 30 feet of sand in the Upper Seventh Zone, development of the Townlot pool was rapid and highly competitive. Five wells were completed by the middle of June, 1941, at initial rates in excess of 1000 bbl per day. The remaining development was completed during the summer of 1941, providing a total of 19 producing wells and 5 dry holes.

†Presented at the spring meeting of the Pacific Coast District Division of Production, API, Statler Hotel, Los Angeles, California, May 6 and 7, 1954.

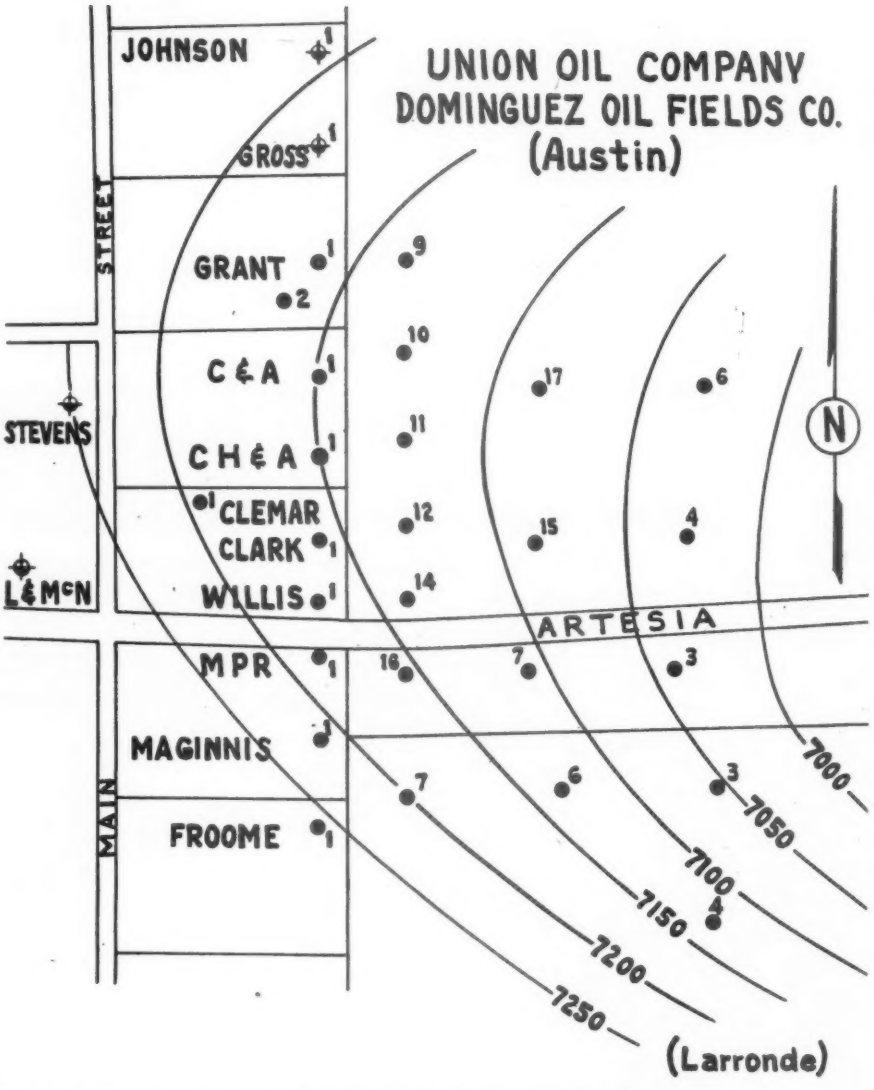

FIG. 1. Contours on top of Pongratz Sand, Dominguez Townlot Area.

As would be anticipated for wide open production from a permeable sand, depletion was very rapid. In June, 1941, the peak production rate for the pool was 5600 bbl per day from 7 wells. This rate of withdrawal, if maintained, would have been sufficient to deplete the pool in about five months.

Stratigraphy, Boundaries

At the time the first wells were drilled, there was no direct evidence that the Seventh Zone Townlot pool was not a part of the main Seventh Zone West Block pool. No stratigraphic discontinuities or faults were known to occur between the two areas, and contours could be drawn smoothly on the entire area. (Fig. 1.) Stratigraphic continuity exists from east to west in the Seventh Zone sands, and the upper Seventh Zone has a uniformly high permeability over the entire west end of the field. Data that will be discussed later indicate the presence of a barrier to migration of fluids in the upper Seventh Zone east of the line of wells — Austin 7, 15, and 17.

Reference to the stratigraphic pene-

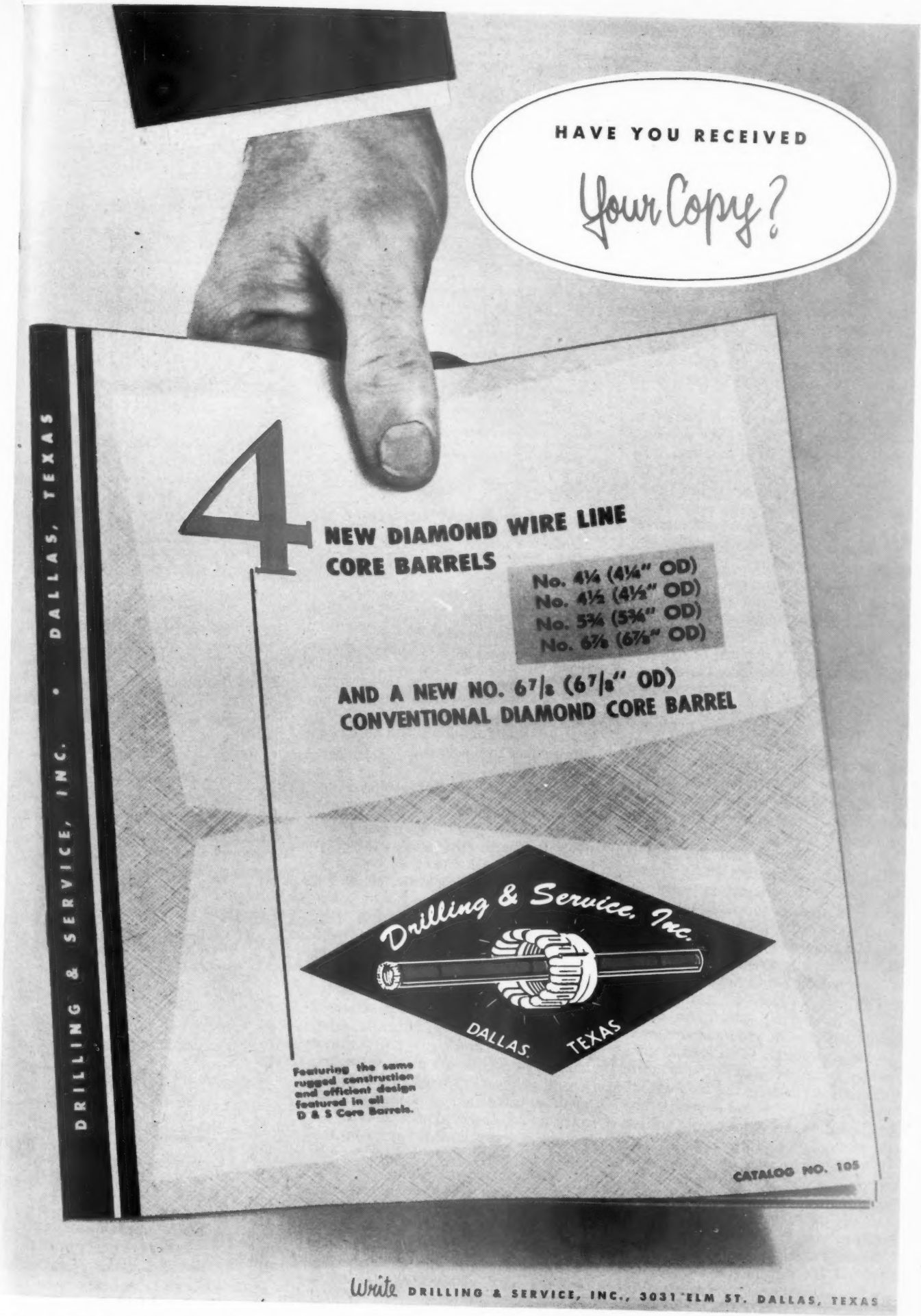
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TABLE 1. Properties of individual sands.

	Pongratz sand	CR sand north area	CR sand south area
Net sand thickness — full penetration	46 ft	12 ft	24 ft
Area — full penetration	35 acres		
Area — total to productive limit	73 acres	30 acres	42 acres
Permeability — arithmetic average	200 md	80 md	170 md
	80 samples	34 samples	20 samples
— geometric average	170 md	40 md	140 md
— standard deviation	1.8	3.6	2.6
— coefficient of variation	0.47	0.71	0.59
Porosity — arithmetic average	26%	24%	26%
Interstitial water saturation	32%	45%	34%
Tank oil capacity — barrels per acre foot	1010	750	980
Acre feet of sand	2490	360	997
Original tank oil in place — barrels	2,515,000	270,000	977,000

tration chart B illustrates the continuity in an E-W direction between the two lines of wells that are on either side of the barrier that segregates the Townlot pool. Austin 4 is east of this barrier, its self potential curve being dotted on the section. The other wells, Austin 7, 15, and 17 are in the Townlot pool.

Principal evidence for a barrier is obtained from a study of the pressure decline history of wells east and west of the barrier. A comparison of the average reservoir pressure in the Townlot pool with the average pressure of wells producing from the same interval in the upper Seventh Zone immediately to the east of Austin 7, 15, and 17 is presented by Fig. 2. The initial pressure discontinuity and peculiar pressure history of the Townlot pool are sufficient evidence for predicting a barrier. Extremely detailed analysis of logs has failed, however, to locate a fault that would provide this boundary. It is probable that a lateral movement with small vertical displacement has served as an efficient barrier to fluid movement in a permeable sand 50 ft in thickness. There is no evidence of important leakage of fluid across this boundary at any time in the pool's history.

The west boundary of the pool is underlain by edgewater with a clearly defined oil-water contact on the northwest flank, but no cored oil-water contact exists on the southwest. Production data indicate that the contact is slightly tilted, lying possibly 15 to 20 ft lower on the south flank.

The Townlot reservoir is constituted of two producing sands, the upper designated the CR sand and the lower the Pongratz sand. The CR sand thins rapidly from the south to the north (penetration chart A) and has been divided into a north and south portion for consideration of reservoir volume and production performance.

The Pongratz sand is the principal source of production for the pool. The high rate of production in the summer of 1941 was largely from the Pongratz sand, which is a relatively homogeneous sand body about 50 ft thick. Table 1 summarizes physical properties and reservoir volumes for different portions of the pool, and a summary of data concerning the properties of reservoir fluids and recovery is presented in Table 2.

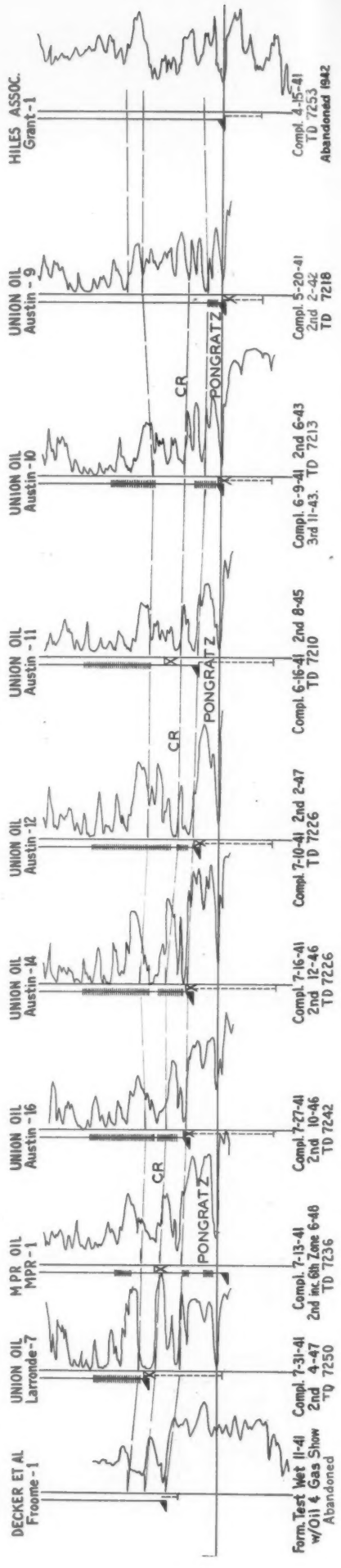
TABLE 2. Reservoir data.

Reservoir depth: Subsea depth indicated. Approximate surface elevation 40 ft.		
Oil water contact	7200 ft	
Top structural contour	7090 ft	
Mean structural contour	7150 ft	
Closure	110 ft	
Mean height above O-W contact	50 ft	
Original tank oil in place	3,762,000 bbls	
Reservoir temperature	210 F	
Original reservoir pressure	2740 psia	
Original gas-oil ratio	600 cu ft/bbl	
Bubble point pressure (Safe and Lacey Dominguez Crude)	2760 psia	
Original oil formation volume	1.36 bbl per bbl T.O.	
Oil gravity	32 deg API	
Original tank oil in place — summary		
CR sand — north		270,000
CR sand — south		977,000
Pongratz sand		2,515,000
		3,762,000
Well spacing		
Total number of wells drilled		24
Producing wells completed		20
Original total productive acreage		70
Well spacing — acres per well		3.5
Recovery data	Barrels	Per cent tank oil in place
Estimated from CR north	60,000	23.0
Estimated from CR south	390,000	40.0
Estimated from Pongratz sand	1,200,000	47.7
Total recovery Townlot pool	1,650,000	43.9

Production, Depletion

The wide open production from closely spaced wells in the comparatively thin permeable sand resulted in very rapid development of high gas-oil ratios, largely concentrated in the low pressure area or region of greatest withdrawal. The gas-oil ratio of Austin No. 2 reached 6000 cu ft per barrel before a rapid decline occurred in August, 1941.

The first gas-oil ratio peak represented the primary depletion phase of production from the Pongratz sand. The CR sand contributed only a minor amount of production prior to the first gas-oil ratio peak. The edgewater movement as calculated from material balance, and as observed in edge wells, did not exert appreciable influence on this phase of the production history. The ultimate recovery as estimated by projection of the depletion performance prior to 8-1-41 would have been 23 per cent of the original oil in place if no water-drive had occurred. Without the subsequent movement of edgewater into the pool, the excessive rise in gas-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PONGRATZ

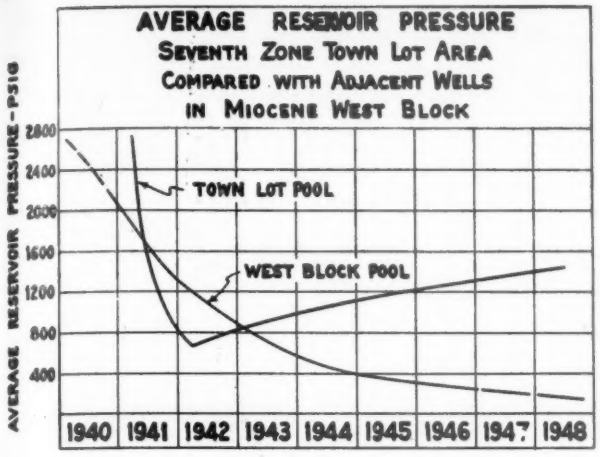

FIG. 2

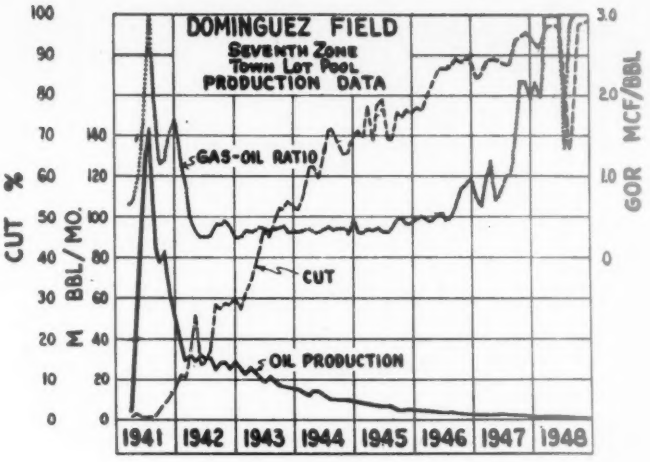

FIG. 3

oil ratio, induced by wide open production, would have resulted in a lower recovery from this pool than would be anticipated from a similar type pool produced at a more conservative rate. Normal depletion recovery from sands similar to the Pongratz would be about 27 per cent of the original tank oil in place for reservoir and oil properties given by Table 2.

Water Drive Phase

The rapid drop of gas-oil ratio following the depletion peak appeared to result from a gas drive. The gas drive preceding the main oil bank presumably resulted from a decrease of gas saturation ahead of the oil front, gas being forced ahead of the oil and simulating a secondary gas drive.

Observe the sequence of events in the pool production history (Fig. 3).

1. A rapid drop of gas-oil ratio attributed to banking of oil ahead of a gas drive. A small increase of oil production also occurred at this time.
2. A secondary rise of gas-oil ratio, resulting when the gas front reached the producing wells.
3. A rapid fall of gas-oil ratio as the gas front is exhausted and the oil bank follows in.
4. The secondary water driven production phase with low gas-oil ratio and slowly increasing cut.

Individual Well Histories

The pool history can best be analyzed by referring to individual well production curves. Four wells were selected from the north area where the Pongratz sand is the principal source of production. Wells are arranged in sequence with respect to the distance to edgewater, the farthest from the edge being Austin 15. It can be observed from detailed observation of the gas-oil ratio peaks and production changes that sequence of occurrence with respect to edgewater will be maintained except for the depletion peak, which occurs practically simultaneously in all wells, the lowest pressure area (Austin 11) having the greatest and most prolonged depletion gas-oil ratio peak.

Austin 9. (Fig. 4) No secondary gas peak occurred, and only very small amount of water drive oil production. Cut rise was extremely rapid. It was thought at first that the casing had split.

Austin 10. (Fig. 5) The secondary gas peak was very slight and there was some water drive oil production. Cut increase was very rapid.

Austin 11. (Fig. 6) The secondary gas peak was fully developed and associated with a definite increase in oil production just preceding it. A considerable increase in oil production can be noted ahead of the water front. Cut increase is less rapid than for Austin 9 and 10. This might be attributed in part to the greater distance traveled by

The Author

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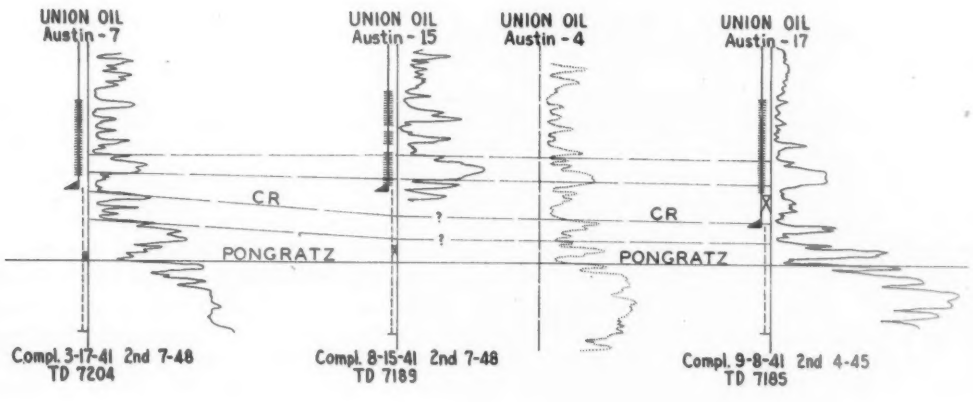
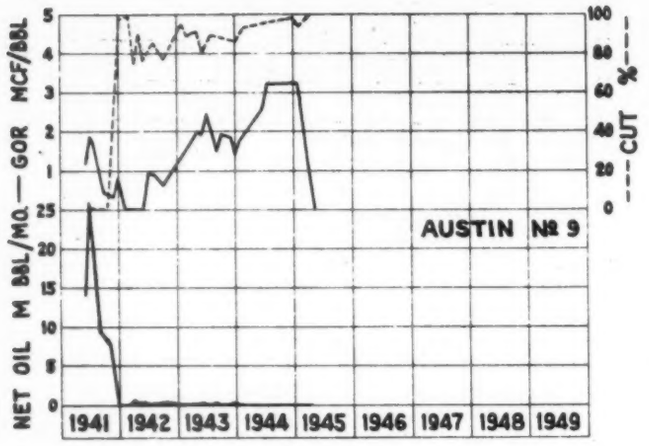
←**Penetration Chart A, Dominguez Field, Datum line top of Pongratz Sand.**

Penetration Chart B. Dominguez Field, Seventh Zone Townlot Pool, Datum line top of Pongratz Sand. →





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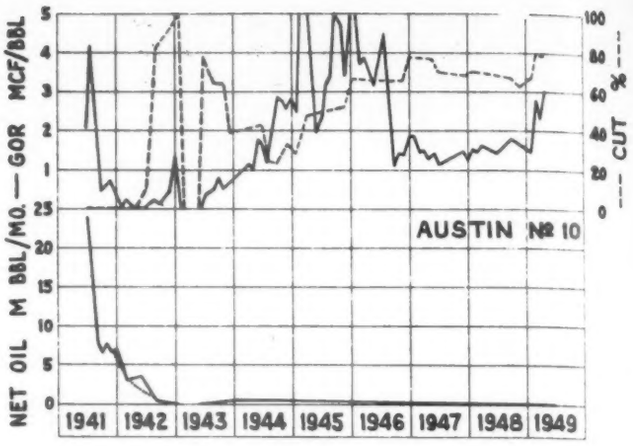

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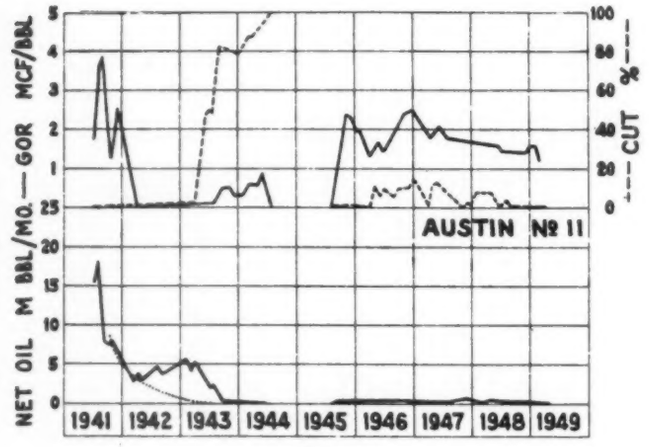


FIG. 6

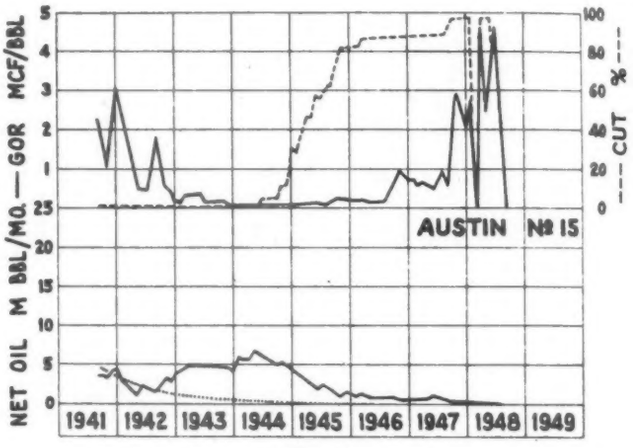
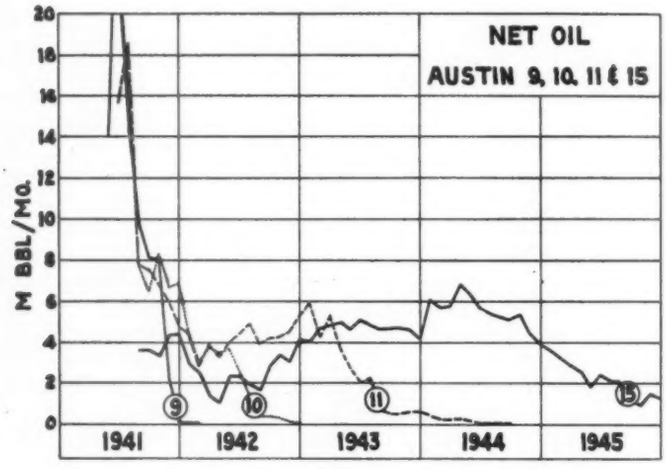


FIG. 7



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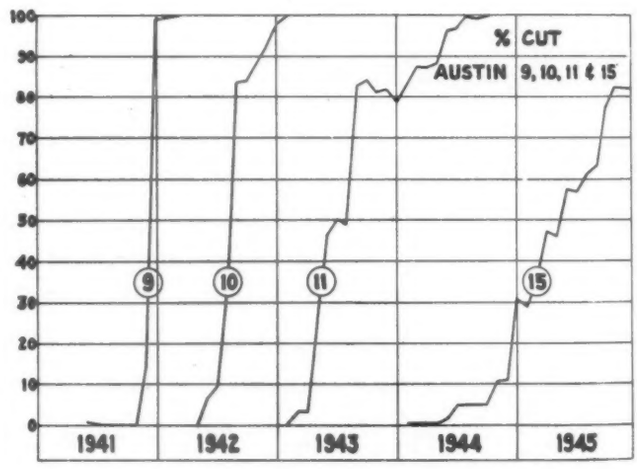

FIG. 9

the water, but Austin 11 has the CR sand above the Pongratz open to production. This sand was probably not subject to water encroachment because of its low permeability and may have been contributing some oil in the period after the cut reached 90 per cent.

Austin 15. (Fig. 7) Two secondary gas peaks are indicated for Austin 15 on the production curve, but the short period of apparent low ratio occurring in April, May, and June of 1942 followed a period of curtailment during which the well was down 30 days at various intervals. In any case an appreciable volume of gas was produced during 1942 ahead of the oil bank which came late in 1942. The cut rise is considerably more prolonged than for the other wells. Subsequent selective production tests of the CR sand that was isolated from the Pongratz interval by means of a plastic-capped plug indicate that this interval was depleted, but had not gone to water.

In order to provide a clear illustration of the water-drive recovery mechanism, the cut and production rate curves of the four wells previously discussed have been superimposed.

The curves of oil production for Austin 9, 10, 11 and 15 (Fig. 8) show the manner in which the oil production bank increased in size with increasing distance from the original edgewater.

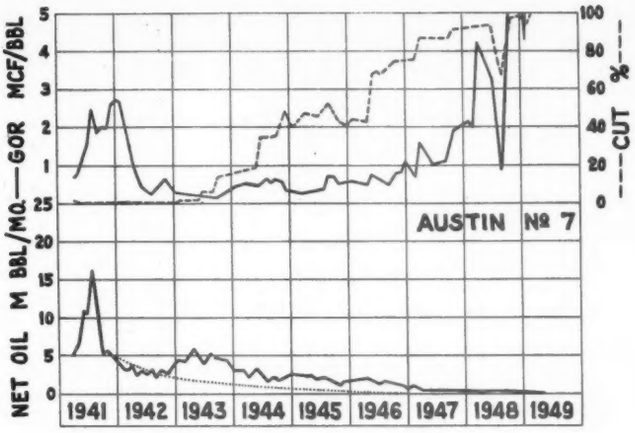

FIG. 10

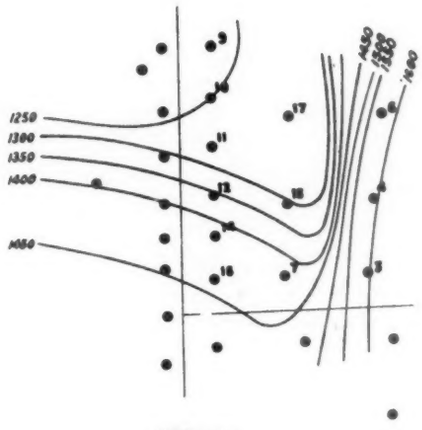

FIG. 11

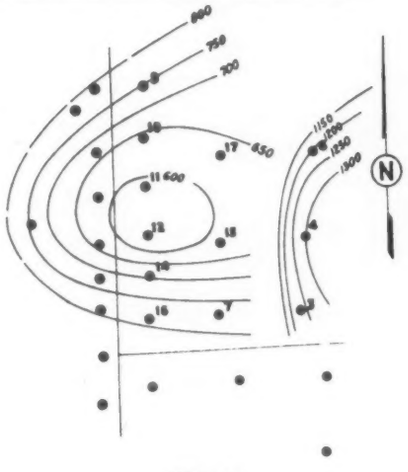

FIG. 12

The curves of water cut for the four wells (Fig. 9) illustrate the gradual attenuation of the water front with distance traveled. The cut rise is very rapid, even in the case of Austin 15. It may be noted that peak production from the oil bank was attained just prior to the first appearance of water in the wells. It should be emphasized that the very rapid rise in cut for these wells is peculiar to the reservoir conditions that exist:

1. The Pongratz sand has a very small variation of permeability.
2. Only a single sand of importance is present in the wells.
3. The water drive was exerted uniformly on the sand, as the small amount of shale present appears to lack continuity.
4. The mobility ratio $\frac{Krw}{Uw} \cdot \frac{Uo}{Kro}$ is low.[1]

Each of the four factors exerts a favorable influence on the water drive recovery from the Pongratz sand. It might be concluded that the recovery would approach the optimum for low-pressure water drive in a moderately deep California reservoir.

Austin 7: (Fig. 10) This well was selected as typical of production from the area where the CR sand has developed considerable thickness and permeability. It can be observed that the production history reflects in part the performance of the Pongratz sand, but that the relatively thick and permeable interval in the CR sand has exerted considerable influence on the well history. The minimum gas-oil ratio between the two peaks was only slightly lower than either peak. Some of the other wells in the CR sand south of the permeability discontinuity had no decrease in gas-oil ratio. The cut history of Austin 7 is considerably prolonged in comparison with Austin 15, demonstrating that the interval is less homogenous.

In order to determine the water drive recovery from the pool, it is important to know the degree of invasion of the CR sand by edgewater on the south flank. To determine whether or not this sand was flooded at Austin 7, the Pongratz sand was plugged off with plastic and the CR sand tested separately. The gross potential of the well was considerably reduced, but production was entirely water. From this test it must be concluded that water has encroached, at least in part of the CR sand on the south side of the pool. It cannot be determined whether the CR sand was completely invaded by water, but it appears probable that the recovery has been in excess of 30 per cent from this interval in the south area.

Maps indicating the pressure, cut and other data on wells in a pool are frequently of value in studying the details of performance. Three sets of such maps have been prepared for the Townlot wells.

1. Isobaric maps showing pressure conditions on the dates shown under Figs. 11, 12, 13, and 14.
2. Cut maps showing water cut conditions on the dates shown under Figs. 15 and 16.
3. Maps showing the chronology of cut development as shown under Figs. 17, 18, 19, and 20.

Study of the maps will demonstrate the nature and direction of the water drive.

Isobaric Maps

The Isobaric maps show the movement of the low pressure region which originally developed from high withdrawal rates from Austin 9, 10, and 11 and the 4 offsetting Townlot wells. At the start of the water drive phase, 4-1-42, water encroachment from the north had caused a southward movement of the pressure sink. This southward movement continued as the water continued to encroach from the north.

Cut Maps

The cut maps do not clearly indicate the direction of water encroachment, although the more rapid change of cut on the northwest side of the pool is evident.

Chronology Maps of Cuts

The isochron maps of cut demonstrate most conclusively the mechanism of water encroachment in this pool. Water advanced nearly symmetrically with the contours at low cut, as indicated by the 20 per cent cut map. This cut was probably largely from bottom water in the Pongratz sand that was quickly evident in all edge wells. The same tendency for cut to increase symmetrically on the edge is evident for the 50 per cent cut isochron. The 80 per cent isochron indicates a nearly static condition for water movement on the south and west flanks of the pool, and the water drive of importance is seen to come from the north. The 99 per cent cut isochron is a more conclusive demonstration of the north to south advance of the principal water drive.

Production Data

Production cumulative curves for Townlot pool are shown on Fig. 21. Recovery from the depletion phase is estimated at about 900,000 bbl. Ultimate recovery is 1,650,000 bbl. This is a recovery of 234 bbl per acre foot by depletion and 428 bbl per acre foot total recovery by depletion and water

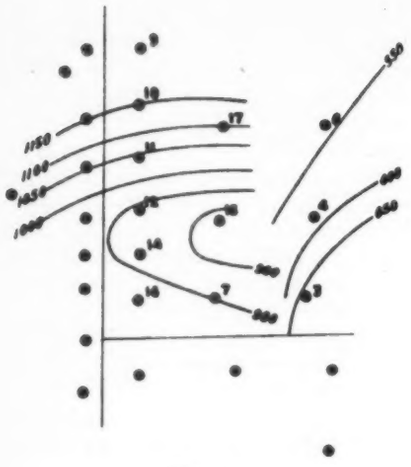

FIG. 13

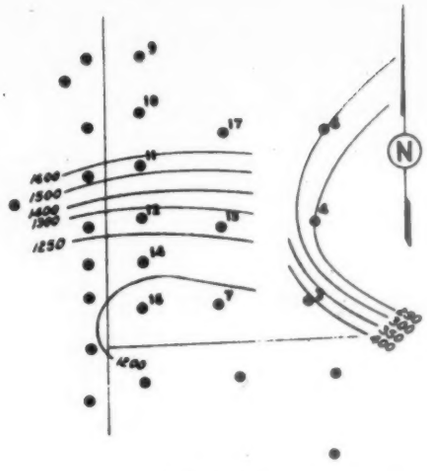

FIG. 14

TABLE 3. Summary estimated recovery data various production mechanisms.

	Apparent depletion recovery		Calculated non-segregated gas drive to 17,000 G. O. R.	Water drive
	Open flow	Controlled production		
Recovery	23 per cent	27 per cent	32 per cent	48 per cent
Comparison of recovery with method for prediction of water drive recovery proposed by Dykstra and Parsons:[1]				
Physical factors:			Source:	
Permeability variation		0.47	Core analysis	
Permeability to oil		11 md	Well productivity at time of maximum oil bank	
Permeability to water		6 md	Hurst influx calculation[2]	
		1 md	Well productivity after flood out	
		1-2 md	Gradients from isobaric maps	
Viscosity of oil		0.85 cpe		
Viscosity of water		0.28 cpe		
Calculation for Pongratz sand:				
Mobility ratio		$\frac{2(.85)}{11(.28)}=0.552$		
Coverage		0.96[1]		
Lateral coverage		0.80 estimated		
Recovery swept area		0.47[1]		
Estimated recovery unswept area		0.20 estimated		
Recovery predicted by Dykstra and Parsons[1]		0.42		
Recovery — actual		0.48		

drive. The increment of recovery that would be attributable to low pressure water drive is 194 bbl per acre foot.

Summary

In summation, the following conditions have been determined regarding the performance of the Townlot pool:

1. It is segregated by an unknown pressure barrier from the main Seventh Zone West Block pool. No known or inferred transfer of fluids has taken place across this barrier.

2. Final recovery of oil has been the result of water drive from the north in the Pongratz sand, which is the most important producing unit.

3. The CR sand is unimportant north of a line of stratigraphic discontinuity which passes between Austin 7 and 15. Recovery from CR sand in this area can be assumed to be the result of a depletion mechanism.

4. The CR sand south of the stratigraphic discontinuity was at least partly water invaded and the recovery can be assumed to range from 30 per cent up to about 40 per cent.

5. A distinct depletion production cycle occurred in the Pongratz, and it is possible to extrapolate the apparent depletion recovery for the pool.

6. A short period of gas drive production preceded the water flood recovery in the Pongratz sand. It is possible to calculate the apparent gas drive recovery from data provided by this phase of the production history, although the results are more uncertain than for the extrapolated depletion recovery.

7. Table 3 summarizes the recovery comparisons made for different production mechanisms and also provides a comparison of water drive recovery with a published method of prediction.

Acknowledgment

The writer wishes to express gratitude to the management of the Union Oil Company of California for permission to present the performance data for this pool.

Many helpful suggestions for the study of this pool were obtained from John E. Sherborne and Carl A. Steiner of the Union Oil Company.

The assistance of J. P. Pedretti, R. L. Boyes, and N. B. Clark of the Union Oil Company in preparing this study is gratefully acknowledged.

References

1. "The Prediction of Oil Recovery by Waterflood" — Dykstra and Parsons, API Paper No. 801-24K. 5-1948.
2. "Water Influx into Reservoir and Its Application to the Equation of Volumetric Balance" — Wm. Hurst, Trans. AIME 1943.

Comments by:

Paul B. Mallory*

Wade has presented an interesting and well prepared paper on the Dominguez Seventh Zone Townlot pool.

This pool's performance record is of particular interest because two different types of recovery mechanism provided the predominating expulsive force during distinctly separate periods in the same reservoir, and because the entire performance history to depletion is available for study. Thus, it is possible to compare recovery efficiencies for the two types of mechanism. Further, a basis is provided for considering the extent to which ultimate recovery might be influenced by controlling withdrawal rates in either a gas depletion drive or a water drive pool.

Depletion by internal gas expansion drive was sufficiently complete to allow an accurate estimation of the ultimate recovery that could have been obtained by that mechanism alone. The author had adequately demonstrated that for this reservoir recovery by water drive was approximately double that obtainable by gas depletion.

In considering possible ultimate recovery by the gas depletion process, the author states that:

"Without the subsequent movement of edgewater into the pool, the excessive rise in gas-oil ratio, induced by wide open production, would have resulted in a lower recovery from this pool, than would be anticipated from a similar type pool produced at a more conservative rate."

The thought that restricting withdrawal rates would have reduced gas-oil ratios and thereby increased ultimate recovery must presuppose that gas liberated from solution would have been conserved in the reservoir and that the final cumulative gas-oil ratio would have been reduced. This is, of course, what happens in a pool when a secondary gas cap forms and is taken advantage of by restricting upstructure withdrawals.

It would like to ask the author if any calculations have been made that indicate gas-oil segregation could have taken place in this pool; how much production rate restriction would have been necessary to cause segregation; and how much longer it would have taken to deplete the pool. In some gas depletion type pools restricting pro-

*Senior production engineer, Long Beach Oil Development Company.

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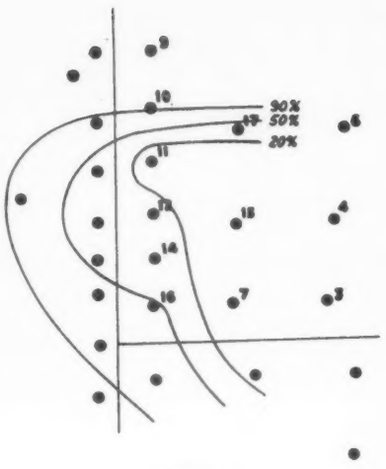

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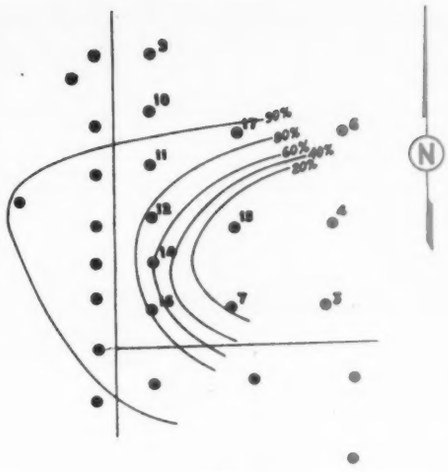

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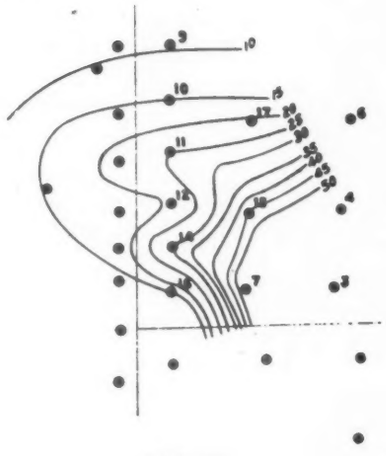

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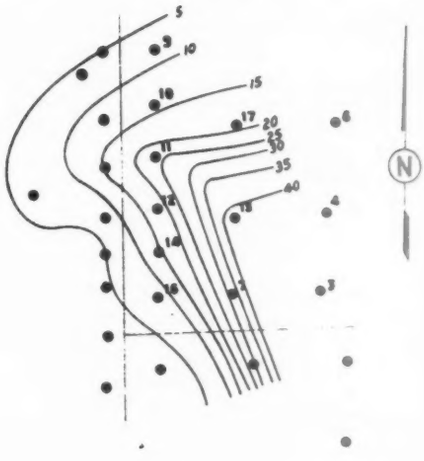

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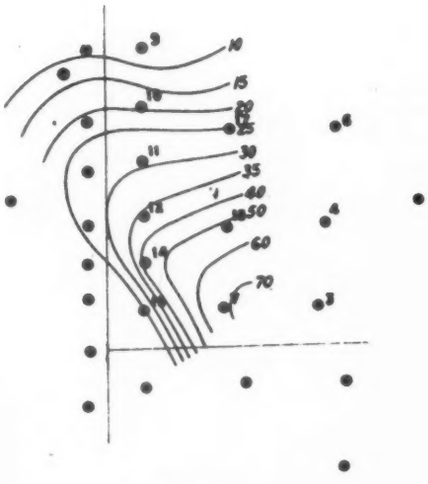

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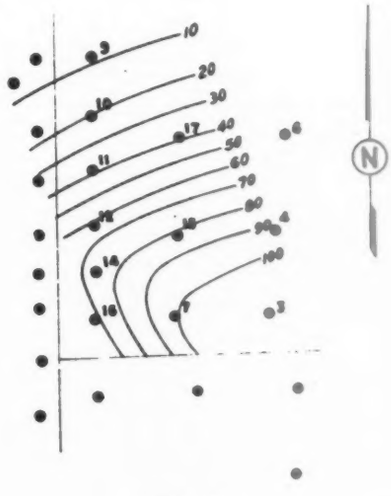

FIG. 20

duction rates to cause secondary gas cap formation is uneconomical because of added production time required.

In the overall performance of this pool, any possible loss of oil production due to dissipation of gas energy may have been of little importance in view of the subsequent water drive performance. When the water drive that developed is taken into consideration, there are some reasons to believe that actual recovery was higher than could have been obtained had early production rates been restricted. Under curtailment conditions the rate of water encroachment would have more nearly kept pace with the rate of withdrawal, and this would have prevented the reservoir pressure from dropping so low.

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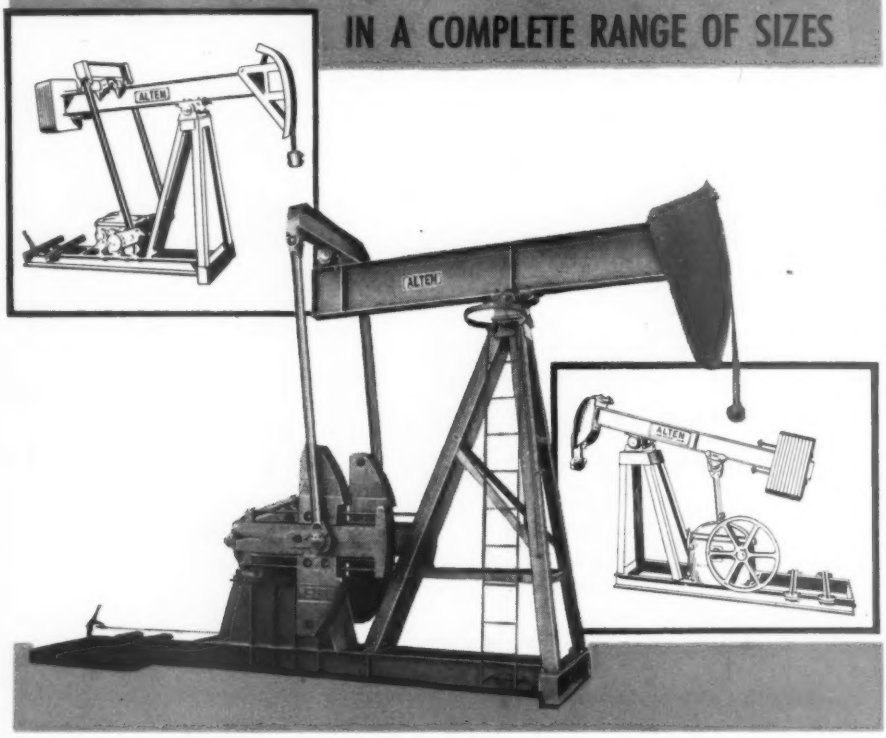

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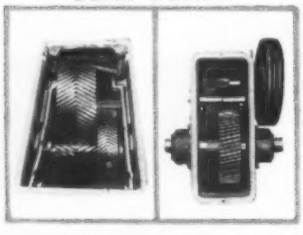

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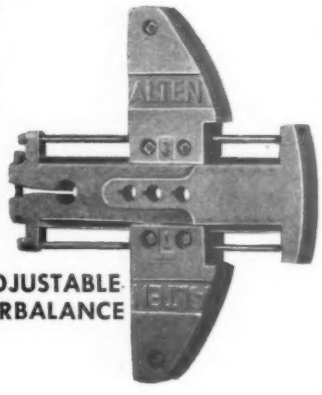

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gesting that under the latter conditions recovery would have been less. These are as follows:

1. The possibility of increasing oil recovery by injecting gas ahead of water in flooding operations has been given a considerable amount of attention recently. In this pool the secondary production peak and secondary rise of gas-oil ratio occurring after the initial depletion peak may have been an indication of such an increase in recovery due to the presence of a free gas phase in the sand. Had early production rates been controlled, and the pool pressure decline restricted, less gas would have come out of solution to form an expanding free gas phase.
2. Some laboratory data have indicated that the lower the oil saturation at the start of a water drive, the lower will be the final residual oil saturation after a sand is flooded out. Therefore, it may well be that the ultimate recovery from this pool was enhanced by the high degree of desaturation that took place during the first year of the pool's history.

Any comments the author may have to offer regarding these suggestions will be appreciated.

Comments by: N. van Wingen*

The availability of reliable oil recovery data is an essential requisite for many petroleum industry problems. The significant advances achieved during the last decade in the field of reservoir engineering have provided a number of analytical procedures to adequately determine future recoverable oil. It is to be borne in mind, however, that the determination of ultimate recovery is not a routine procedure, but one that requires a considerable amount of interpretive analysis. It is for this reason that papers such as the one presented by Mr. Wade are of great value, as they provide a means of correlating the results of the customary recovery prediction calculations with actual pool performance.

Empirical data of this nature are relatively scarce as the older fields generally lack the necessary basic reservoir data while pools developed since the advent of modern techniques have usually not reached a sufficient degree of depletion.

As is pointed out in the paper the early rate of pool taking was considerably in excess of the one at which the edge water could intrude. Accordingly,

*Petroleum engineer, South Pasadena, California.

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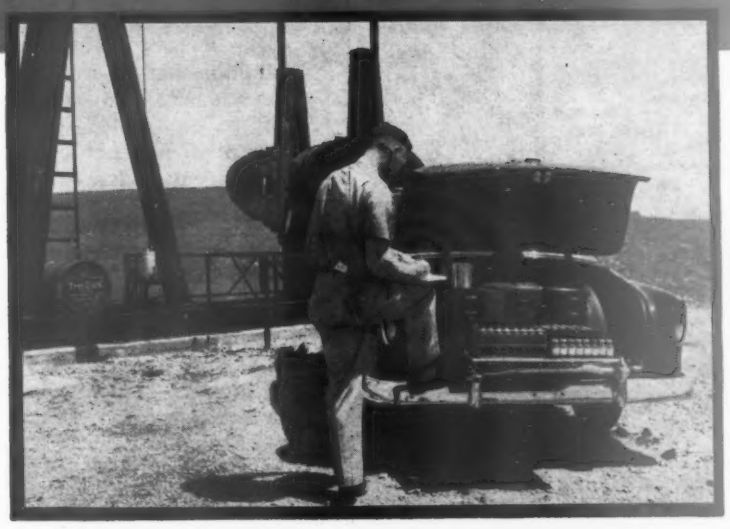

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the dominant reservoir mechanism during this period was that of an internal gas drive. It is to be borne in mind, however, that during this phase the water, nevertheless, effected a certain degree of pressure sustenance, so that the performance mechanism was really that of a partial water drive rather than a true internal gas drive mechanism. Therefore, I would like to ask Mr. Wade whether the 23 and 27 per cent ultimate recovery figures indicated for the depletion phase of pool operations include the effect of the encroaching water; if so, has an attempt been made to determine what the ultimate recovery would have been if no water movement at all had taken place.

Analytical procedures which predict future recoverable oil are generally based upon an extrapolation of relative permeability ratio, Kg/Ko data. I would like to inquire to what extent such prediction calculations for this pool were confirmed by its subsequent actual depletion performance history. Some reservoir analysts hold that Tarner type predictions can be made for water drive reservoirs provided future water incursion is determined by the Hurst method and is included in the calculations. I would be interested to know to what extent this pool's water drive phase history corroborated such prediction calculations.

Reply of author (F. R. Wade) to Van Wingen and Mallory

I would like to thank Van Wingen and Mallory for their excellent and thoughtful questions. I will try to answer them as briefly as possible.

Van Wingen's first question deals with the statement in the paper that the recovery from the Dominguez Townlot pool during the depletion phase of pool performance would have been 23 per cent of the tank oil in place if subsequent water encroachment had not taken place. It should be emphasized that this recovery is calculated on the assumption that the water drive mechanism was not effective during the early stages of the pool's history. The recovery of 27 per cent was cited as the possible ideal recovery to be obtained by the depletion mechanism if no effective water encroachment had taken place.

Van Wingen also mentions the use of the relative permeability ratio — gas saturation relationship as a means of extrapolating pool recovery from past performance. The recovery calculations mentioned above were made on such a basis. Fig. 22 is a plot of relative permeability ratio data for the Dominguez Townlot pool. The 23 per cent recovery was calculated using an extrapolation of the relative permeability ratio curve for Austin No. 11, which compares closely with the curve calculated from Ten Section field data. This curve was selected as typical of the depletion performance of the pool and reflects very little influence from water drive. The actual pool performance curve is also plotted and shows a deviation from the curve used for calculating pure depletion performance, which is probably the result of the limited influence of encroaching edgewater during the pool's early history.

The ideal depletion recovery of 27 per cent was calculated from an extrapolation of the Dominguez Miocene West Block pool curve.

Examination of pool performance Krg/Kro curves for the Dominguez Townlot reservoir supports the conclusion that it would be very difficult to make Tarner type prediction calculations for a combination drive reservoir unless the pool production was restricted during the early phases so that a true depletion phase did not exist. It is considered that the difference exhibited by the Krg/Kro curves of Fig. 22 reflects an actual difference in the nature of the flow processes taking place in the reservoir and is not a result of inaccuracy in the method of reservoir analysis such as computation of the pool gas saturation. Laboratory relative permeability data confirm that hysteresis is exhibited by relative permeability data depending on the direction of change of saturation; that is, the Krg/Kro curve may be anticipated to be different for increasing and decreasing gas saturation. Furthermore, it has been observed in field performance that a considerable difference in relative permeability will be exhibited as a result of different rates of withdrawal for depletion type reservoirs. The writer thinks that this is an unsteady flow phenomena not readily observable in laboratory scale experiments in which the lenses of high permeability within the individual sands act as selective carriers of gas during the periods of high rate of pressure decline. The concentration of gas saturation in the high permeability lenses will result during conditions of high drawndown where no external driving medium exists in adequate quantity to maintain liquid saturation by displacement. This condition will be accentuated by a large variation of permeability, large volumes of gas in solution, and a high initial formation volume factor for the liquid phase.

Summarizing conclusions regarding relative permeability curves of Fig. 22:

1. The difference in average Krg/Kro curve for the depletion phase of Townlot pool wells and the Dominguez Miocene West Block

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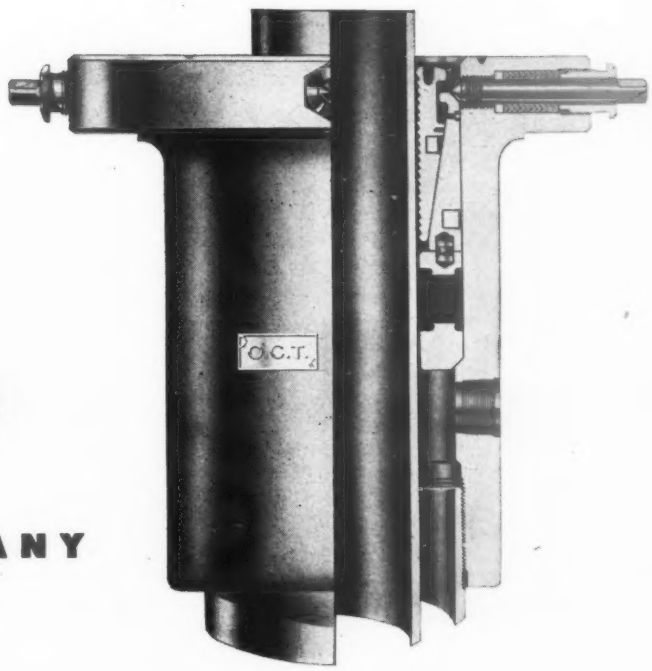

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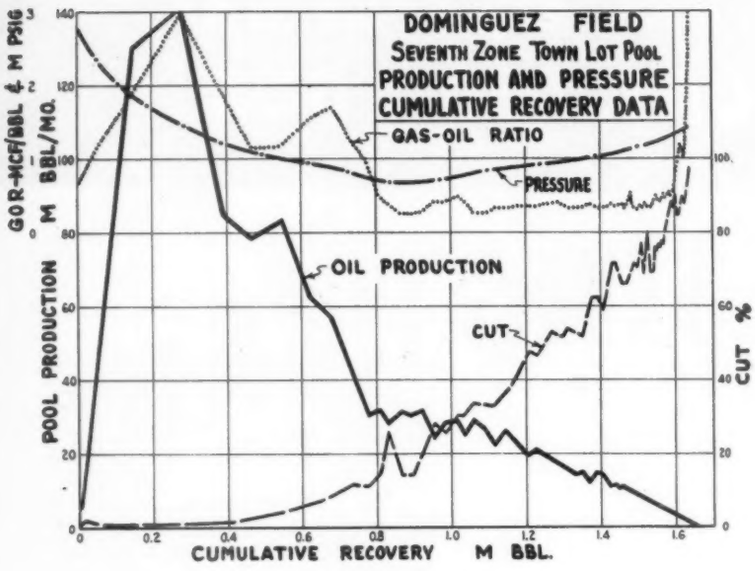


FIG. 21

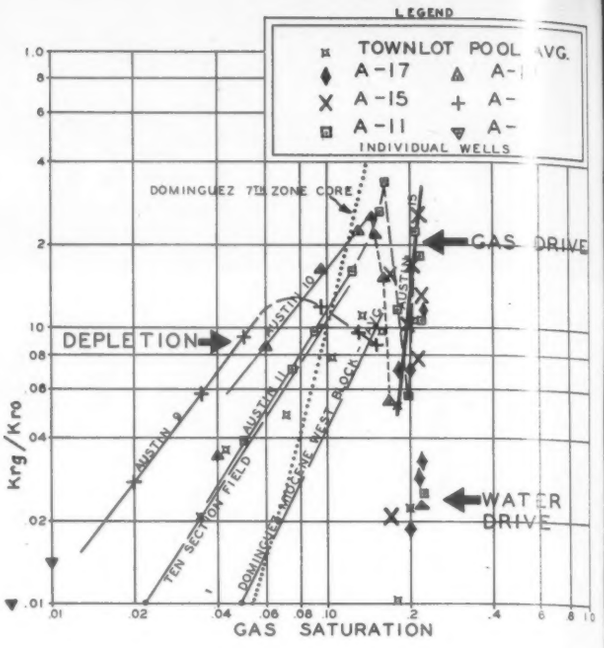


FIG. 22

pool is due principally to the difference in rate of depletion of reservoir pressure which resulted in selective withdrawals of gas as explained above for the Townlot pool.

2. The difference in average Krg/Kro curve for Dominguez West Block pool and Ten Section field results from inherent differences in properties or reservoir sand, principally permeability variations and to some extent differences in reservoir fluid properties. Both pools have been produced under closely controlled production rates to achieve minimum subsurface waste of gas.
3. The difference in Krg/Kro curves between the depletion phase and the gas drive phase of Townlot pool history illustrates the difference in relative permeability to be expected in a uniform sand as a result of external gas drive compared with the internal depletion process at high drawdown. Actually it is expected that the gas drive Krg/Kro curve in an ideal uniform reservoir should closely approximate the laboratory Krg/Kro curve on Fig. 22. The internal depletion Krg/Kro curve for uniform sand at small drawdown should also approach values for laboratory data.
4. Krg/Kro data for water drive phase illustrate the hysteresis exhibited by laboratory data during imbibition and indicate that an encroaching water front can result in a very rapid change of gas-oil ratio without a corresponding large decrease of gas saturation.

Contrary to Mallory's assumption, the writer does not consider that the formation of a secondary gas cap is essential to increase recovery by the depletion mechanism. As would be inferred from the previous discussion of Krg/Kro curves, it is my conclusion that restriction of production rate alone will, in many cases, result in reduced producing gas-oil ratio. As a matter of fact, the gravitational mechanism is not apparent as a part of the depletion recovery performance in the adjacent West Block pool. Selective withdrawal of down-structuring wells has not been exercised in this pool, although selective withdrawal of low gas-oil ratio production was practiced during the flush stages of production.

The maximum time necessary to achieve the same hypothetical depletion recovery in the Townlot pool as that in the West Block pool would be equivalent to the time required to deplete the West Block pool. The discovery of this pool was in 1938, but the first major production was taken in 1939. At the present time the recovery from the West Block pool is 23 per cent of the tank oil in place, or the same as the calculated recovery for the unstricted depletion performance of the Townlot pool. Thus, it would have required 15 years to deplete the Townlot pool at the same rate as the West Block pool.

Under non-competitive conditions five wells or less would have been drilled to develop the Townlot pool and would have provided an adequate drainage pattern considering the geological conditions that prevail. Based on the West Block pool average, these wells would be producing 11 bbl per day apiece at the present time. The average production rate for the past 15 years would have been 32 bbl per day per well and the ultimate recovery would be 200,000 bbl per well for controlled depletion performance and 27 per cent ultimate recovery. The question of the economic wisdom of this procedure as against drilling 24 wells and depleting the pool in 12 months appears obvious. It is outside the scope of this discussion to delve further into the economics of optimum spacing, rate of depletion and present worth.

In order to examine Mallory's second hypothesis quantitatively, it is reasonable to assume that the gas depletion phase of the Townlot pool production ended on April 1, 1942. This is the time of reversal of the pressure decline trend and also represents the flattening of the gas-oil ratio trend and production decline trend. At that time the pool recovery was 21.7 per cent of the tank oil in place, and the accumulative produced gas-oil ratio was 1675 cu ft per barrel. At the pool average pressure of 690 psia, material balance calculation indicates a negative water encroachment.*

*For the Pongratz sand only, recovery at this time was estimated to be 25.7 per cent of the tank oil in place, and the average pressure was 635 psia. Material balance calculation indicated a water encroachment rate of over 2000 bbl per day into the Pongratz sand for the previous six months. This rate checks fairly closely with the water encroachment constant calculated by Hurst's method for the following six-year period and tends to confirm the calculations.

The discrepancy between the calculations for the pool average data and the calculations for the Pongratz sand results from the fact that the pool pressure more nearly reflects the behavior of the Pongrantz sand than the overlying, less depleted CR sand; hence, the static well pressures are too low to represent a true pool average. Isobaric maps for 8-1-41 and 4-1-42 (Figs. 11 and 12) illustrate this point. It will be observed that no pressure data exist for the most southerly wells in the pool where the CR sand is the thickest and most productive. Hence, pool pressures largely represent the Pongratz sand during the depletion phase. These details are developed to explain the reason it is not possible to obtain a good material balance indication of water encroachment from the production and pressure data prior to 4-1-42.

Let it be assumed, for the sake of an example, that during the early phase of restricted production to the time that the same recovery is achieved (21.7 per cent for the pool) the pool production rate would be controlled to maintain a cumulative gas-oil ratio of 840 cu ft per barrel.

The following comparison can then be made between recovery from a water drive pool by wide open production and recovery by controlled production to prevent a high rate of pressure decline early in the pool history. It is assumed that the same final pressure of 1450 psia will be obtained for each method of production.

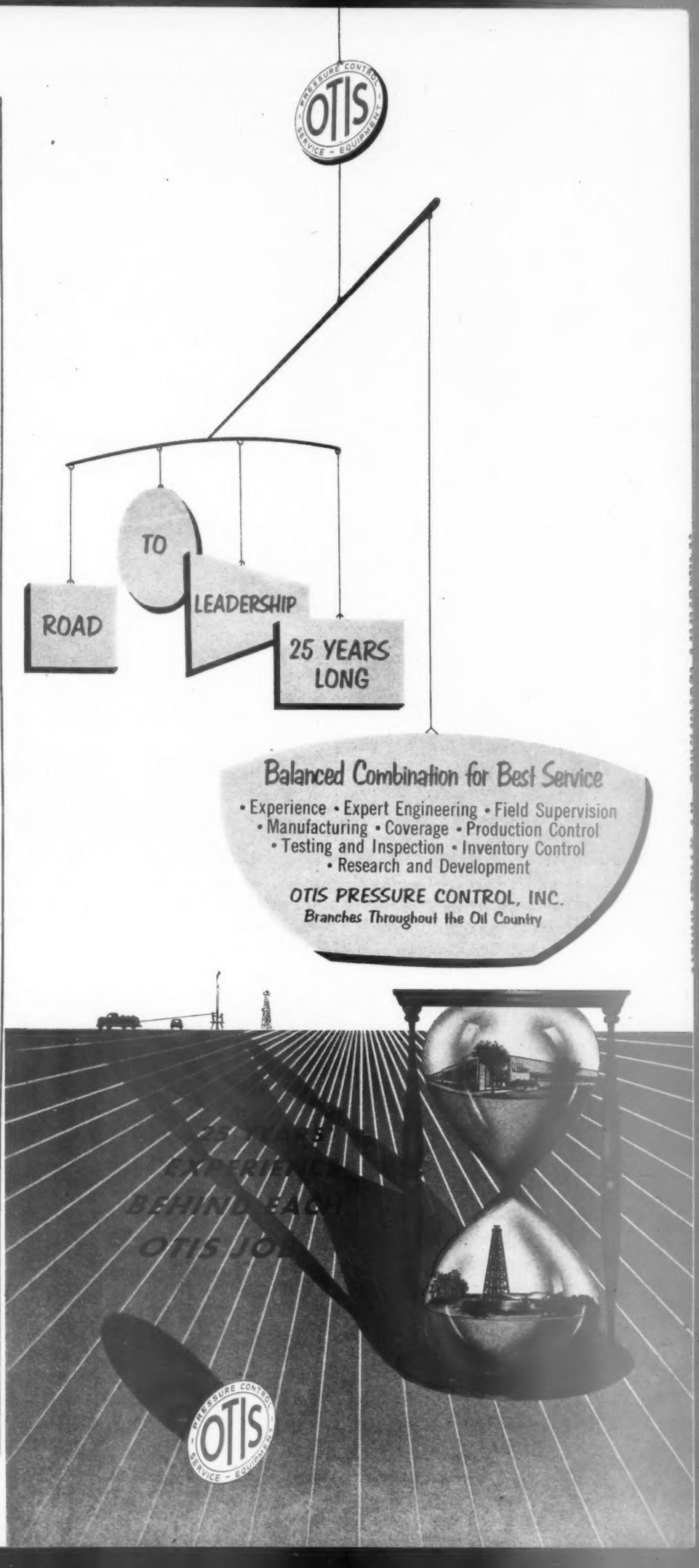
Dominguez Townlot pool water drive recovery.

	Actual conditions as computed by material balance for wide open production (per cent)	Calculated conditions as computed by material balance for controlled production (per cent)
Pool		
Residual oil saturation.....	32.8	21.3
Residual gas saturation....	5.0	16.5
Total residual hydrocarbon.	37.8	37.8
Pongratz sand		
Residual oil saturation....	31.0	17.0
Residual gas saturation....	0.0	14.0
Total residual hydrocarbon.	31.0	31.0
Per cent recovery		
Pool.....	43.9	63.6
Pongratz sand.....	47.7	71.3

The joker in this calculation lies in the assumption that the total residual hydrocarbon saturation is constant irrespective of its relative composition of free gas and oil. This, of course, is the trend of present thinking regarding the recovery of hydrocarbons from sands by water displacement, and is largely substantiated by laboratory data.

The presence of inital free gas saturation is, of course, no guarantee that free gas will exist behind the oil bank and ahead of the waterfront. For the Townlot pool depletion had progressed to the point that when resaturation of the sands took place by the banked up oil, most or all of the free gas was forced back into solution and could serve very little purpose in displacing residual oil from the flooded out sand.

I agree in kind, but differ in detail with Mallory that some degree of pressure decline in water drive is desirable. Each case must be examined separately. Some reservoirs with a very high variation of permeability and unfavorable mobility ratio would be affected adversely by any type of water drive. Hence, depletion before water flooding would be desirable. For a uniform sand such as that of the Dominguez Seventh Zone Townlot pool, recovery by water drive with partial pressure maintenance would result in a high recovery. * * *



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In digging slush pits, water pits, or rotary pits the "No-Pushbeam" design of the 9X or 15X results in a "yards ahead" dirt mover. The blade is mounted on the main frame, and a steeper penetration angle is afforded. The "positive down pressure" on the blade provided from this design bites down into hard material—the steep blade angle reduces length of ramp, saves time and waste of long approaches. The deep, narrow blade handles a big vertical load with Baker's famous "roll action" ease that means more dirt moved. Finishes pits in the shortest possible time. (Advertisement)

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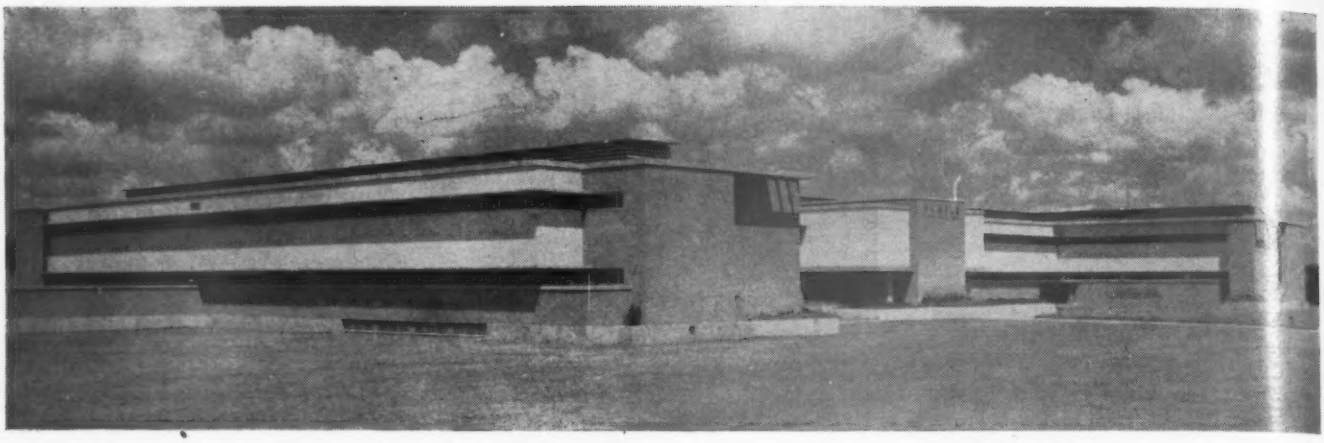

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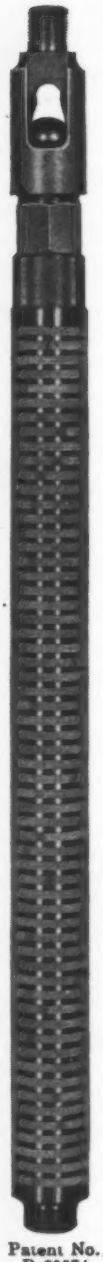

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Humble President Hines H. Baker dedicated the Center at public ceremonies following an open house for employees the previous night. Tours of the center gave the public a chance to see the two "electronic brains," complex laboratory instruments, and other equipment the scientists use in their research work.

The new Center provides some 330 scientists, technicians, and assistants who formerly worked in separate locations with the newest scientific equipment in a single center.

Research in the Houston Center is divided into two phases: Exploration research, which seeks to advance the search for new oil reserves to meet present and future needs; and production research, concerned with the problems of drilling for oil, of bringing it to the surface, and of developing fields so that the greatest amount of oil will be recovered. Product and refining research is carried on at the company's Baytown Research Center, opened in 1951 to consolidate research activities at Baytown Refinery.

Humble now has almost 600 employees devoting full time to a broad research program that costs between $5 and $6,000,000 per year.

★ ★ ★

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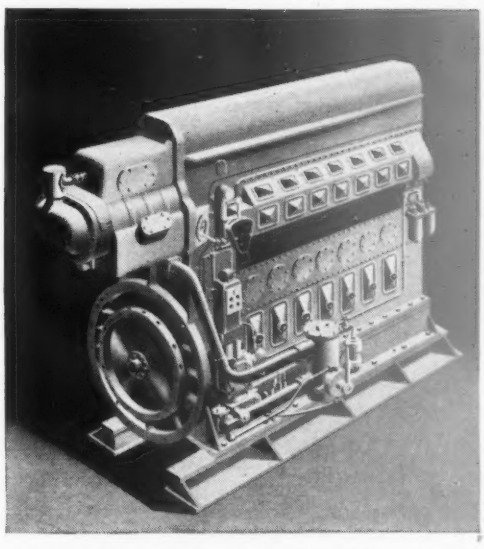

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PUMPS

J. H. Boggs,* E. C. Fitch,* A. T. Woods*

THE drilling operation is dependent for its success on the successful operation of a variety of pumps of many types and sizes. Origin of the pump is not known; references to the use of pumps to provide water is found in the records of the ancient civilizations of Egypt, China, India, Greece, and Rome.

More recently much credit is given to H. R. Worthington who invented the direct-acting steam pump in 1840, and who introduced poppet valves for the reciprocating pump in 1850. His developments gave impetus to many fields where the pump was a necessary fixture. Although the reciprocating pump is perhaps the major interest to the drilling industry, the centrifugal pump is also an important device. This type pump has been in use for over 100 years, but only since 1900 have improvements been of such a nature to make its use possible in many instances.

Fundamentals

In order to get an insight into some of the problems involved in pumps and pumping, some definitions and terminology must be reviewed. The power required to drive a pump depends on its capacity and on its total head. The term "head" refers to a pressure or a pressure difference expressed in feet of the flowing fluid or sometimes feet of water. It may be converted to pressure in psi by:

$$P = \frac{h \times \delta}{144}$$

where:

h = head in feet of the flowing fluid

δ = density in lb per ft^3

The total head derives from several sources; the static suction head or lift and discharge head, the change in velocity of the stream being pumped, and the head required to overcome frictional resistance.

Total static head is illustrated in Figs. 1 and 2. It will be noted that this amounts merely to the change in elevation which the pump brings about for the liquid in these simple cases.

*School of Mechanical Engineering, Oklahoma Institute of Technology, Oklahoma A & M College, Stillwater, Oklahoma.

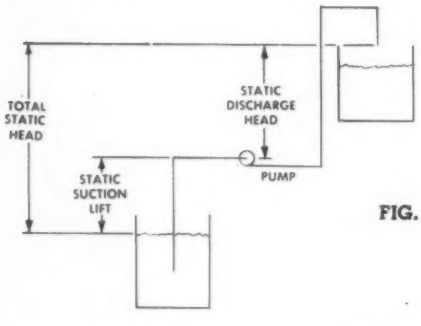

FIG. 1. Suction lift and free discharge.

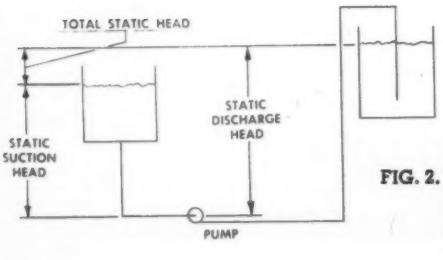

FIG. 2. Static suction head and submerged discharge.

Many other illustrations could be given for cases of varying suction head or lift and varying discharge head. Cases where the pressure on the surface of either the suction tank or discharge tank is other than atmospheric must also be computed in a more complex manner.

The head due to velocity change of the flowing fluid is calculated as follows:

$$V = \frac{Q}{A} \quad \ldots \ldots \ldots \ldots \ldots \quad (1)$$

V = velocity in feet per second
Q = flow rate in cubic feet per second
A = area of pipe or duct in square feet

$$\text{Total velocity head} = \frac{V_d^2}{2g} - \frac{V_s^2}{2g} \quad \ldots \ldots \quad (2)$$

where subscripts
s = suction
d = discharge
g = acceleration due to gravity. 32.2 ft/sec^2

There are also several factors which contribute to the resistance head of the pump.

1. **Shape of the entrance to the pipe**
2. **Obstructions within the pipe (include valves and fittings)**
3. **Bends in the pipe**
4. **Sudden enlargements in the pipe**
5. **Sudden contractions in the pipe**
6. **Friction within the pipe**

In order to obtain values for the first five of these factors reference may be made to any of various handbooks or textbooks in the field. They are generally given as equivalent feet of straight pipe or in terms of velocity head.

The sixth factor may be found from similar sources but Table 1 shows vividly how the frictional resistance varies with pipe size and capacity. While Table 1 gives representative values for water, in an actual case the amount of friction in the pipe depends on the velocity, density of the fluid, and on the viscosity of the fluid in addition to the pipe size.

Any calculation of power required to drive a pump must be based on the factors shown. On an existing installation, pressure gages may be placed at the pump on suction and discharge lines; these gages may be used to measure all of the factors except velocity head. In the case

TABLE 1. Friction of water in pipes.†

Loss in pounds per square inch (psi) for each 100 ft of straight smooth pipe due to friction.

	Size of pipe in inches						
GPM	1 in.	2 in.	3 in.	4 in.	6 in.	8 in.	10 in.
10	3.16	0.12					
25	19.00	0.67					
50		2.44	0.34	0.09			
100		9.46	1.31	0.33	0.05		
200		37.50	5.02	1.22	0.17	0.04	0.01
300			11.20	2.66	0.37	0.09	0.03
400			19.50	4.73	0.65	0.15	0.06
500			30.08	7.43	0.96	0.25	0.09
600				9.54	1.41	0.38	0.14
700				14.32	1.89	0.47	0.18
800					2.38	0.61	0.22
1000					3.88	0.94	0.32

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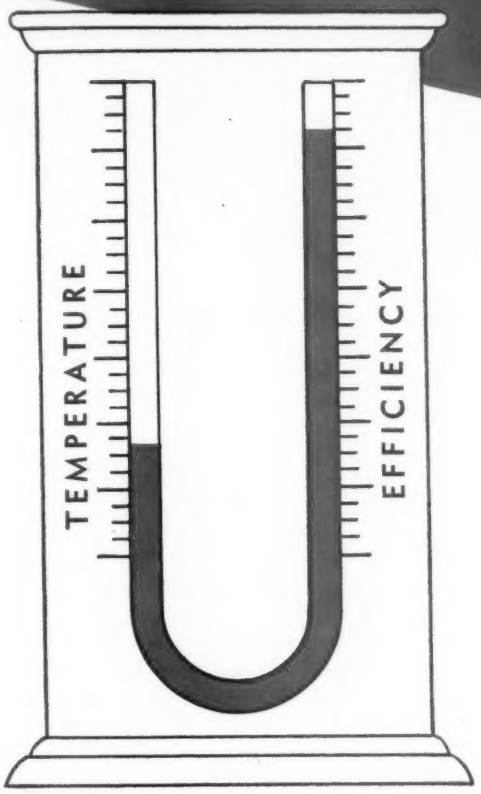

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where liquids are pumped, the rate of flow in cubic feet per minute is the same on both sides of the pump and with areas about equal for the suction and discharge pipes the velocities are about equal. This means that the total velocity head is negligible and that the pressure gages can be used in the determination of all the power required.

As an example to show the effect of head on power required consider the slush pump and the changing requirements imposed on it by the drilling operation. As shown in Fig. 3 the mud flows down the drill pipe and through the nozzle or ports at the bit. It then flows up out of the hole through the annular space between the drill pipe and the wall of the well.

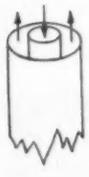

FIG. 3 Mud flow diagram.

If it is necessary to maintain at all depths a velocity of about 3 ft per sec in the annular space, a certain rate of flow for a given set of dimensions of the drill pipe and bit is required. As the velocity and thus the flow rate can not change, it can be seen that as the hole gets deeper the pump must supply more pressure at discharge to overcome the frictional resistance due to increased length. (The pressure losses in surface equipment do not vary greatly with depth).

A more theoretical approach to the problem of pressure drop for the Newtonian flow of fluid proceeds as follows:

$$\Delta P_f = \frac{f\delta V^2 L}{8\ gr} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where:

ΔP_f = pressure drop due to friction in psf.
f = D'Arcy friction factor
δ = density of fluid in lb per ft^3.
V = average velocity of the fluid in ft per sec.
L = length of pipe or duct in ft.
g = acceleration due to gravity, 32.2 ft per sec^2.
r = hydraulic radius.

$$r = \frac{\textit{cross sectional area}}{\text{wetted perimeter}} \text{ (in general)}. \quad \ldots \quad (4)$$

$$= \frac{D}{4} \text{ (for a circular section)}.$$

$$= \frac{D_2 - D_1}{4} \text{ (for an annular section)}$$

Where:

D = diameter in feet of inside of circular section.
D_1 = inner diameter and D_2 = outer diameter of annular section.

Fig. 4. shows that the friction factor varies with the Reynolds number. The Reynolds number is given by:

$$R = \frac{\delta V 4r}{g\mu} \quad \text{where } \mu = \text{absolute viscosity in lb sec per ft}^2 \quad \ldots\ldots \quad (5)$$

$$= \frac{\delta VD}{g\mu} \text{ (for a circular section)}$$

$$= \frac{\delta V(D_2 - D_1)}{g\mu} \text{ (for an annular section)}$$

Fig. 4 is the result of experimental determination of pressure drop in flow over a long period of years. Roughness is shown to have an effect on the friction factor. The factor "k" represents the average height of the surface irregularities.

The formulae presented above have been combined in various forms and with various units to make them more useful to the engineer. Pigott presented such a set of formulae in 1941 which are useful to the solution of problems. It is important to understand, however, the origin of such equations. It should also be understood that if an empirical relation for friction factor versus Reynold's number is used that the resulting final equation for pressure drop may look quite different from equation number (3).

Pump Technology

Priming. A fundamental principal of pumping which applies to all pumps is that the working chamber must be purged of air or vapor before fluids can be lifted or drawn into the chamber. Once this is done the fluid will be pushed into the chamber by atmospheric pressure acting on the source and will be caught and expelled into the discharge line by the moving member of the pump. The operation of purging air from the working chamber consists simply of filling the chamber with the fluid to be pumped and is referred to as "priming."

Centrifugal pumps must be primed each time they are started, unless they are equipped to be self-priming, whereas reciprocating pumps usually need to be primed only once, that being when they are put in operation. This is because the cylinders in reciprocating pumps will usually remain full of fluid when the pump is shut down.

Packing. The packing used in a pump is also of vital concern. It is used to prevent leakage between the moving and nonmoving members of the pump and usually consists of rings of hemp, flax, nylon, rubber, or soft metal. Mechanical packing is also used occasionally on centrifugal pumps and depends on a very close fit between parts. Re-

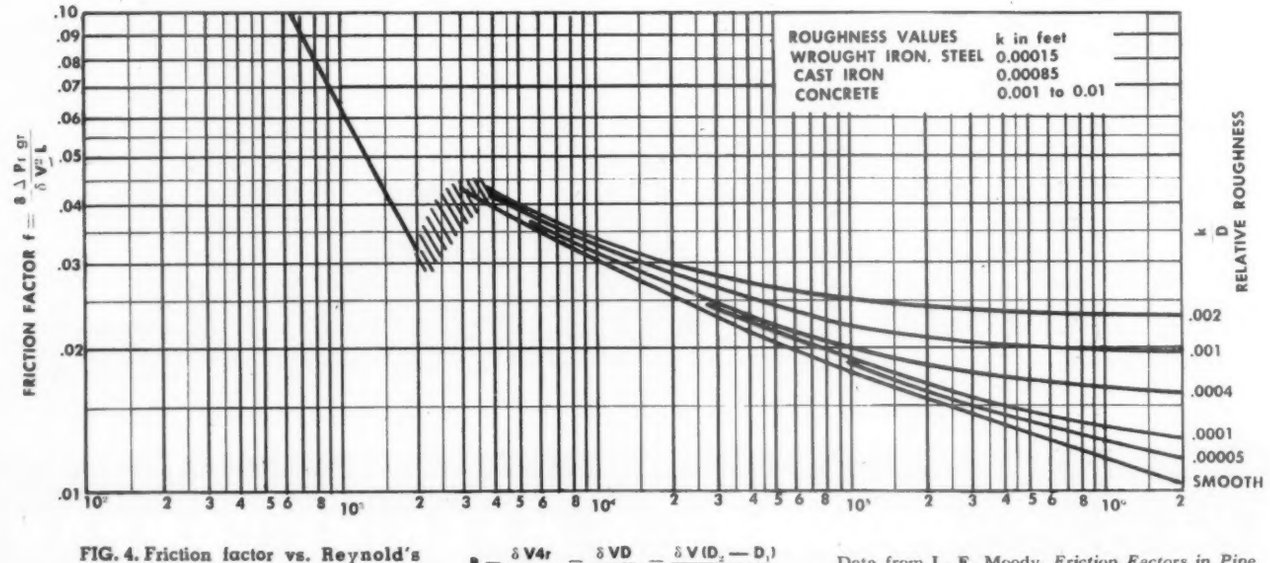

FIG. 4. Friction factor vs. Reynold's number. $R = \frac{\delta V 4r}{g\mu} = \frac{\delta VD}{g\mu} = \frac{\delta V(D_2 - D_1)}{g\mu}$

Data from L. F. Moody, *Friction Factors in Pipe Flow*, Trans. ASME, vol. 66, p 671, 1944.

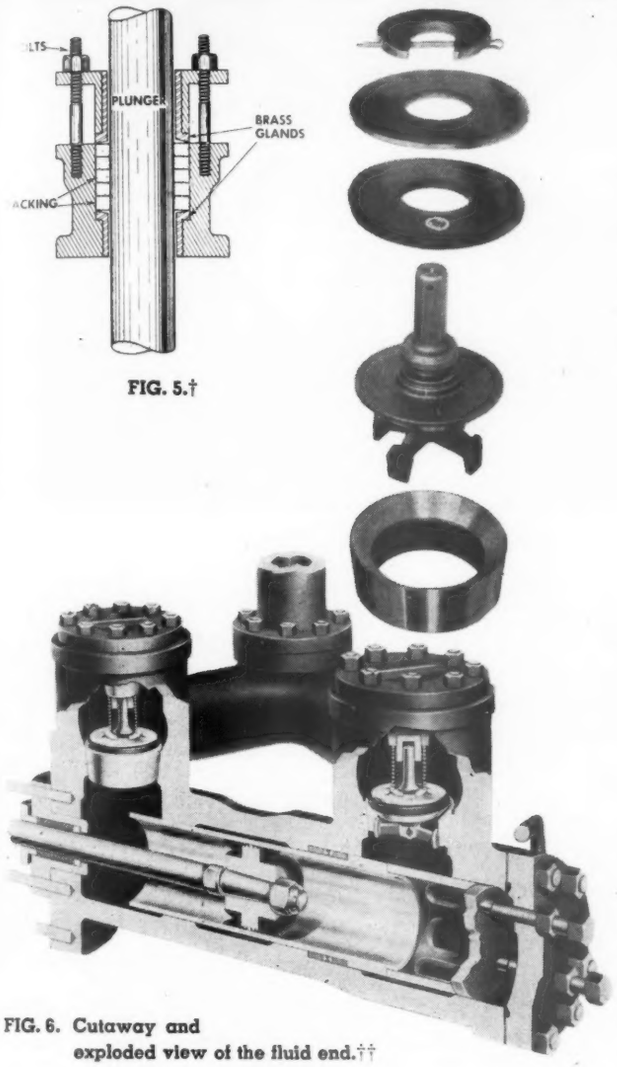

FIG. 5.†

FIG. 6. Cutaway and exploded view of the fluid end.††

ferring to Fig. 5, it can be seen that as the stuffing box is tightened the packing is forced tighter against the rod or shaft.

The packing in most cases depends on a slight leakage of the fluid being pumped for its lubrication, thus, a stuffing box that is too tight will soon overheat and burn out the packing or score the shaft. It is thus obvious that pumps should not be run when there is no fluid in the working chamber unless an auxiliary lubricating system is used.

At times the abrasive action of the fluid being pumped is so great that no leakage can be permitted. In these instances grease cups or lubricating oils may be used for lubrication. Many modern day slush pumps depend on oil for lubrication of the stuffing box between the connecting rods and cylinder ends.

Any time moving and nonmoving parts exist in the presence of fluid some type of packing must be used. It is important that the correct packing be selected and that it is used properly if the operation is to be economical.

Valves. Two types of valves commonly encountered are the pressure relief valves used on most positive displacement pumps and the inlet and discharge valves used on reciprocating pumps. Table 2 shows the operating characteristics of some of the more common pumps and indicates where valves are necessary.

Relief valves are usually set to open at a pressure of from 10 to 50 per cent above the normal working pressure

†Shell Pipe Line Corporation.
††National Supply.

TABLE 2. Operating characteristics of the various types of pumps.†

				Reciprocating			
	Centrifugal	Rotary	Triplex	Double acting power	Direct acting steam	Axial flow	Small horiz impact type
Flow	Even	Even	Pulsating	Pulsating	Pulsating	Even	Even
Effect of increasing head							
Capacity	Decrease	None	None	None	Decrease	Decrease	None
Power	Decrease	Increase	Increase	Increase	Increase	Increase	Increase
Effect of decreasing head					Slight		
Capacity	Increase	None	None	None	increase	Increase	None
Power	Increase	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease
Effect of shutting disch. valve		Pressure increases with violently destructive effect				150 to 200 % increase	
Increase press.	15 to 30%	if no relief valve is used.			Increase		Increase
Power	Decrease 50 to 60 %	Power increase to destruction.			Increase	Large increase 100 to 125%	Increase
Valves	None	None	Inlet and discharge valves.			None	None

Courtesy Economy Pumping Machinery Company.
†Finch, *Pump Handbook*, 1948, The National Press.

of the pump. Valves may be of either the spring loaded type or the shear pin type. Valves must be inspected periodically to insure that they will open when necessary to prevent damage yet remain closed under allowable pressures.

The inlet and discharge valves in slush pumps are of the dual-seat wing or rod guided type. In this type valve a steel-to-steel contact withstands the closing impact and carries most of the load exerted by the fluid pressure. A rubber-to-steel contact is also provided to insure against leakage and prevent cutting of the valve seat. The wing or rod on the lower part of the valve keeps the valve in a vertical position to insure proper seating each time the valve closes. A typical valve is shown in Fig. 6.

Air Chamber. The pulsating flow from a reciprocating pump can cause excessive impact loads and consequent failure in equipment if it is not properly controlled. Air chambers mounted on the discharge lines serve to absorb part of the shock through compression of air. Specially designed surge chambers are also available when the surges or pulsations cannot be sufficiently controlled with conventional air chambers. These special chambers are of many designs but the most common are in reality oversized air chambers that are charged with compressed air or gas. Pump efficiencies can sometimes be substantially increased by installing an air chamber on the suction line in order to smooth out the flow into the pump.

Types of Pumps

Reciprocating Pump. This pump is of primary importance in the drilling industry. It is used almost exclusively for mud circulation.

Fig. 7 shows the method of operation. In the general case the moving member is caused to move to the left opening the suction valve and filling the cylinder with liquid. As this member reverses and moves to the right the suction valve is closed and the discharge valve is forced open by the pressure built up in the cylinder.

Reciprocating pumps are substantially self-priming (see

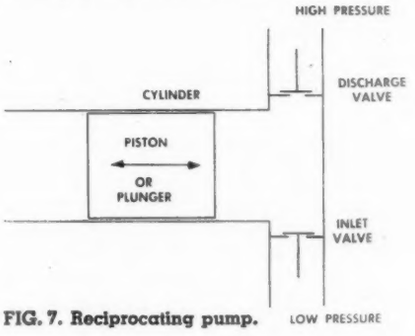

FIG. 7. Reciprocating pump.

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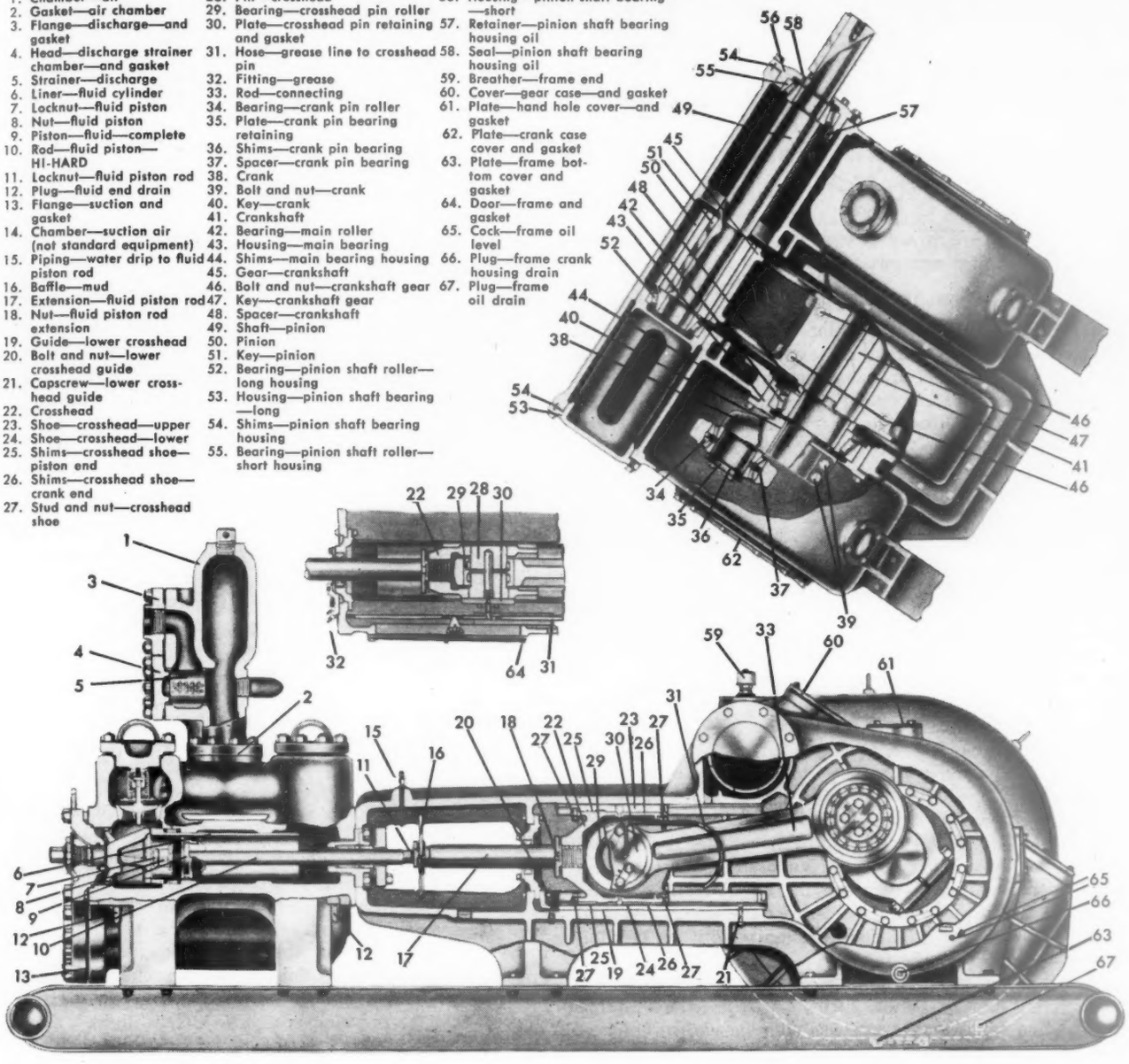
FIGURE 8—Cross-sectional view of a slush pump.†

1. Chamber—air
2. Gasket—air chamber
3. Flange—discharge—and gasket
4. Head—discharge strainer chamber—and gasket
5. Strainer—discharge
6. Liner—fluid cylinder
7. Locknut—fluid piston
8. Nut—fluid piston
9. Piston—fluid—complete
10. Rod—fluid piston—HI-HARD
11. Locknut—fluid piston rod
12. Plug—fluid end drain
13. Flange—suction and gasket
14. Chamber—suction air (not standard equipment)
15. Piping—water drip to fluid piston rod
16. Baffle—mud
17. Extension—fluid piston rod
18. Nut—fluid piston rod extension
19. Guide—lower crosshead
20. Bolt and nut—lower crosshead guide
21. Capscrew—lower crosshead guide
22. Crosshead
23. Shoe—crosshead—upper
24. Shoe—crosshead—lower
25. Shims—crosshead shoe—piston end
26. Shims—crosshead shoe—crank end
27. Stud and nut—crosshead shoe
28. Pin—crosshead
29. Bearing—crosshead pin roller
30. Plate—crosshead pin retaining and gasket
31. Hose—grease line to crosshead pin
32. Fitting—grease
33. Rod—connecting
34. Bearing—crank pin roller
35. Plate—crank pin bearing retaining
36. Shims—crank pin bearing
37. Spacer—crank pin bearing
38. Crank
39. Bolt and nut—crank
40. Key—crank
41. Crankshaft
42. Bearing—main roller
43. Housing—main bearing
44. Shims—main bearing housing
45. Gear—crankshaft
46. Bolt and nut—crankshaft gear
47. Key—crankshaft gear
48. Spacer—crankshaft
49. Shaft—pinion
50. Pinion
51. Key—pinion
52. Bearing—pinion shaft roller—long housing
53. Housing—pinion shaft bearing—long
54. Shims—pinion shaft bearing housing
55. Bearing—pinion shaft roller—short housing
56. Housing—pinion shaft bearing—short
57. Retainer—pinion shaft bearing housing oil
58. Seal—pinion shaft bearing housing oil
59. Breather—frame end
60. Cover—gear case—and gasket
61. Plate—hand hole cover—and gasket
62. Plate—crank case cover and gasket
63. Plate—frame bottom cover and gasket
64. Door—frame and gasket
65. Cock—frame oil level
66. Plug—frame crank housing drain
67. Plug—frame oil drain



priming) but a suction lift for water of about 22 ft under the most favorable conditions is the accepted maximum. This allowable lift decreases rapidly with increase in liquid temperature. These pumps are suited for pumping against very high heads. It is only necessary to maintain a rather slow piston speed when operating against high pressure, high suction lift, or when handling heavy liquids in order to minimize wear.

Because of the method of operation of this type of pump the delivery comes in definite surges which constitutes an undesirable feature in almost every type of service.

For a detailed picture of a modern piston slush pump refer to Fig. 8. Features which should be noted are:

1. The cylinder liner and piston that can be removed and exchanged for other sizes to allow use of one pump for a variety of service.

2. Air chamber used to damp the pulsations in the discharge line and give a smoother flow.

3. Construction of the poppet type valves used on both discharge and suction side. This construction is indicated further in Fig. 6.

4. The pump is double acting—that is, the same series of events occur on both sides of the piston.

5. The construction of the piston is indicated as having rubber rings (cups) built around it to prevent leakage between the piston and cylinder. Fig. 6 shows this construction on a different pump.

6. The packing scheme is shown at the right end of the cylinder.

More space is devoted to this type pump in later sections of this article as it is of prime importance to the drilling operation.

Centrifugal Pump. This machine consists of an impeller mounted in a rotating shaft. A suitable housing encloses the impeller. The fluid enters at the centerline of the shaft and because of the shafts rotation has kinetic and potential energy imparted to it. The housing is so shaped that this energy is converted into pressure as the fluid flows through the housing.

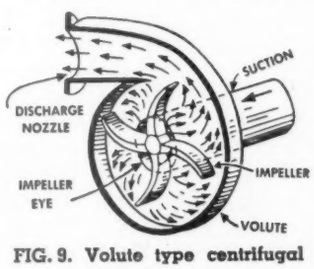


FIG. 9. Volute type centrifugal pump.††

Fig. 9 shows a sketch of

†Oilwell.
††Kristal and Annett, *Pumps*, 1940, McGraw Hill Book Co.

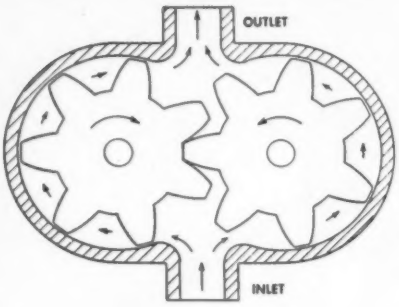


FIG. 10. Spur gear pump.†

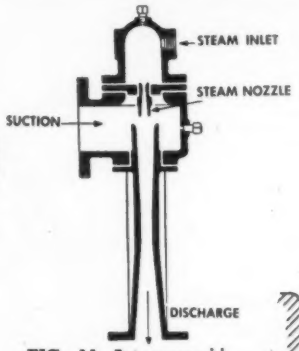


FIG. 11. Jet pump.††

the important parts of the volute type centrifugal pump. The diffuser type of pump is quite similar to the volute type but has an additional stationary member surrounding the impeller which aids in efficient conversion of kinetic energy to pressure. The diffuser type pump is used for high heads and has the additional attribute of balanced radial loading on the impeller.

The centrifugal pump is popular for its simplicity, low cost, and versatility. It is capable of delivering heads up to several thousand feet and will handle high temperature fluids.

This pump may be direct-connected to present day high rpm electric motors to give it another advantage over some other types.

The centrifugal pump may be used where suction lift requirements of approximately 15 ft are the case. Although the suction lift available depends upon the speed of the pump, capacity, and head, 15 ft is generally considered to be a safe value. The safe suction lift will decrease with speed and capacity and increase with increase of head.

Cavitation is a problem which can be encountered in the use of centrifugal pumps. This occurs when the pressure at a point in the pump drops below the vapor pressure of the fluid being pumped. Vapor bubbles then form which causes a sharp decrease in the flow. In addition the pump's efficiency drops because of the energy required to vaporize the fluid. To help prevent cavitation the following measures can be taken:

1. Keep the fluid temperature as low as possible.
2. Avoid use of bends, turns, or obstructions in the suction line which would increase eddying and turbulence.
3. Choice of proper pump upon manufacturers' recommendation for the given installation.
4. Suction line velocities should be kept as low as possible.
5. An emergency measure to control cavitation in the field is to introduce small amounts of air in the suction line. This cushions the shock normally felt when the vapor bubbles collapse on entering a higher pressure region.

On large pumps the problem of installation becomes more complex, especially if direct driven. Care should be taken to align the pump shaft carefully with the power shaft. Needless to say for the larger sizes of pumps the foundation rigidity must be more carefully considered.

It is well to emphasize that the centrifugal pump has a wide range of applications. It is used for practically all types of pumping jobs except where small quantities must be pumped against extremely high heads.

Propeller Type Pump. Although the propeller type pump has seldom been used in the drilling industry, it has some applications and should be mentioned in passing.

This pump can be used for heads lower than about 40 ft and for capacities greater than 300 gpm. It is suitable for drainage, condenser circulating water, and similar duty.

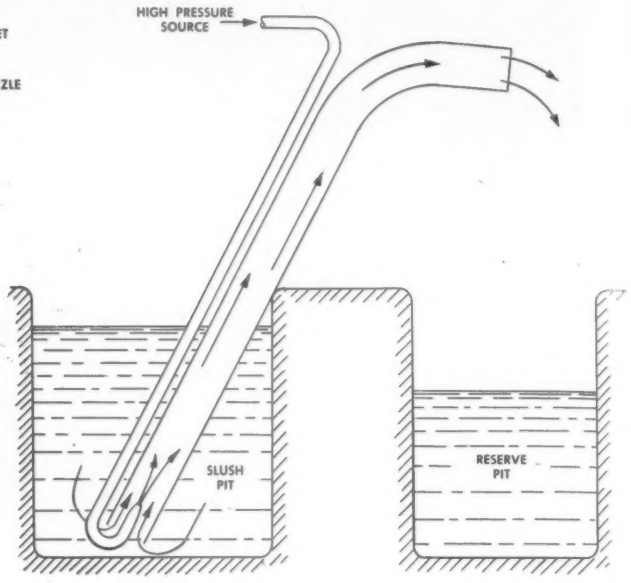


FIG. 12. Jet for cleaning mud pits.

It differs from the centrifugal pump in that the fluid flows along the axis of rotation of the impeller (it is sometimes called the axial-flow pump) and the head is developed by the propelling action of the impeller on the fluid. The fluid enters axially and discharges in an axial direction.

It has the advantage for similar duty over the centrifugal pump in that it would operate at higher speeds. This would enable drive from a smaller motor (dimensions) if electric drive were used.

Positive Displacement Rotary Pumps. This type of pump is widely used for oil pumps in lubricating systems and for hydraulic control systems and hydraulic drives which are becoming more popular on drilling rigs.

In one of its simplest forms this pump consists of two spur gears meshing together and running at a fairly high rpm (Fig. 10). Around these gears is a closely fitted housing. At the inlet the fluid enters the pump and is carried around to the high pressure side between the teeth of the gears. At the high pressure side the fluid is forced out of the tooth space as the teeth mesh together. This positive type action requires the use of a relief valve as an obstruction or valve closure on the discharge side would cause excessive pressures to be built up.

FIG. 13. Jet circulation pump.†††

†R. C. Binder, *Fluid Mechanics*, 1949, Prentice Hall.
††Samuel R. Beitler and Eric J. Lindahl, *Hydraulic Machinery*, 1947, The Ronald Press Company.
†††George E. Failing Company.

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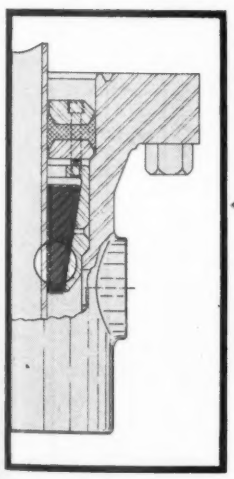

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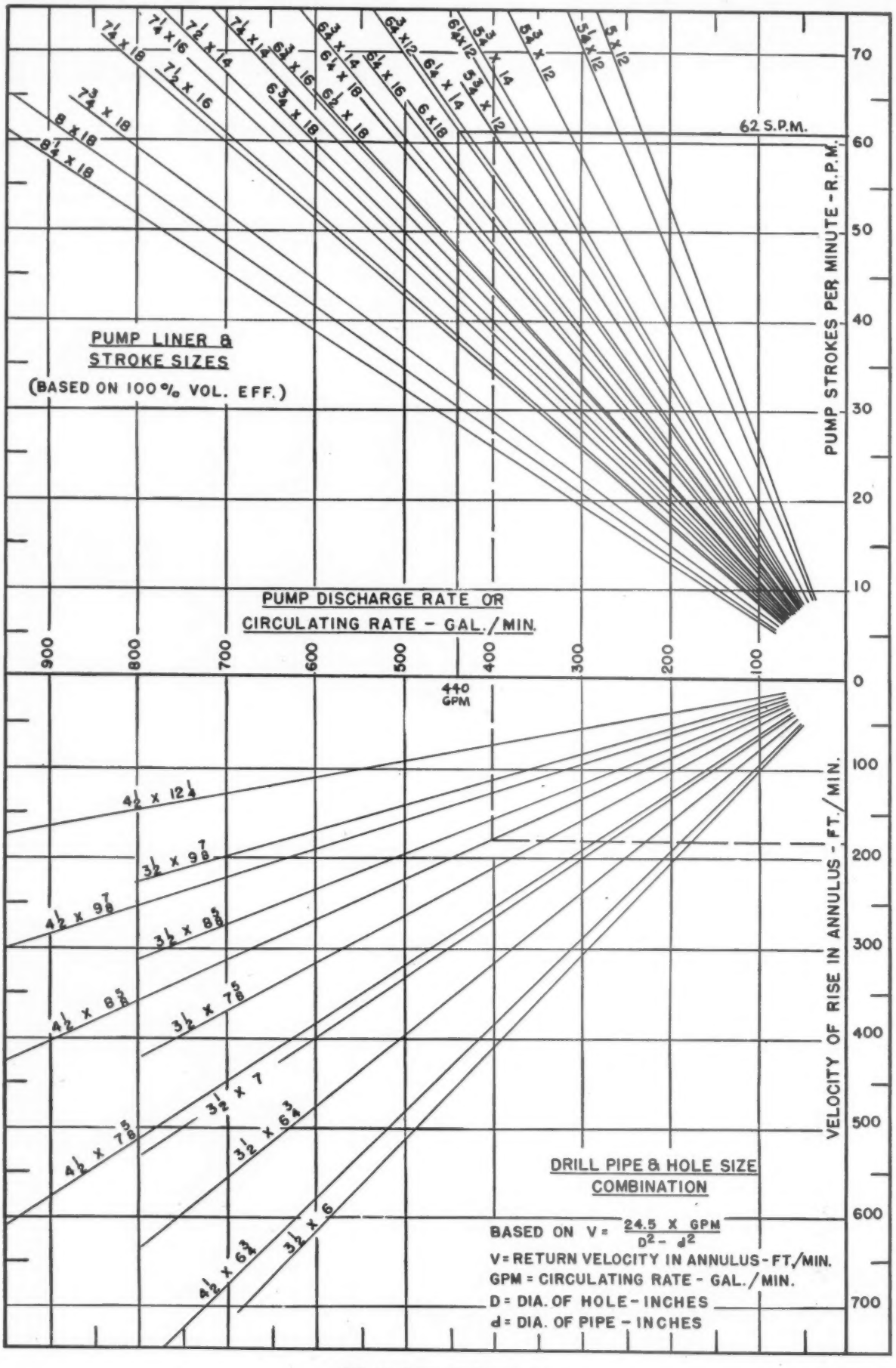

FIG. 14. Pump discharge rate. (Emsco)

There are many variations of this pump, usually in the shape of the two rotating members that mesh together. Helical gears are sometimes used to give a smoother flow as the spur gear arrangement delivers a pulsating flow. In addition, other types of rotary pumps use a sliding or rocking vane in a housing. Internal gears are also used in the same general fashion. Literature references indicate a great number of unique patents on types of rotary pumps.

The advantages enjoyed by the rotary pump are:

1. Continuous flow (some pulsations).
2. Simple construction (no inlet or discharge valve).
3. Small in size for a given capacity.
4. Do not require large foundations.
5. Maintenance and service simple and easy.
6. Suction lift up to 22 feet allowed by the Hyraulic Institute.
7. Thick and viscous liquids may be pumped with ease.

The rotary pump is found in numerous applications around the rig and will operate satisfactorily except for pumping gritty or abrasive fluids.

The Jet Pump. A unique pumping device can be made that has no moving parts. This device is called the jet pump or injector. Some fluid such as air, steam, water, or mud must be available at high pressure. This fluid expands through a converging passage causing an increase in velocity. The high velocity creates a low pressure region which serves as the suction of the pump. The fluid to be pumped enters the low pressure region where it is mixed with the high velocity fluid. This mixture then passes through a diverging passage accompanied by an increase in pressure. Fig. 11 shows a diagram of this device.

It can be used, if compressed air is available, for pump priming around the drilling rig.

A common usage of this type pump is in emptying and cleaning mud pits. In this device a large diameter pipe has inserted into its lower end a small diameter pipe with a choked exit section. The small pipe carries high pressure fluid (air, steam, or mud) which provides the energy for jetting. Fig. 12 is a sketch of this type pump.

A recent development in this field is in the use of a specially designed jet pump for circulating drilling fluid. The rig illustrated in Fig. 13 utilizes reverse circulation and was primarily designed for drilling water wells.

The rig is capable of drilling a 60-in. diam hole to depths below 600 ft. The jet pump will deliver 1500 gal per minute with a small suction head and 600 gal per min at a depth of 600 ft.

Miscellaneous Types of Pumps. The turbine pump is similar to the centrifugal pump in outward appearance. It is quite different, however, in its operating characteristics. Its interior design consists of a rotating disc with short blades around the circumference. Liquid flows into the pump axially and flows out to the periphery of the pump where the blades carry it around to the discharge side as they impart energy to the liquid.

This pump has operating characteristics quite like a positive displacement pump in some respects. For example, the pump has excellent efficiency for capacities up to 100 gpm, develops a high suction lift, and power required increases with discharge head although the capacity decreases rapidly.

There are many other types and variations of pumps in use today. Few of these are of particular interest to the drilling industry. A pump operating with "mixed flow" (between the centrifugal pump action and the axial flow pump action) has some uses but it not generally used at

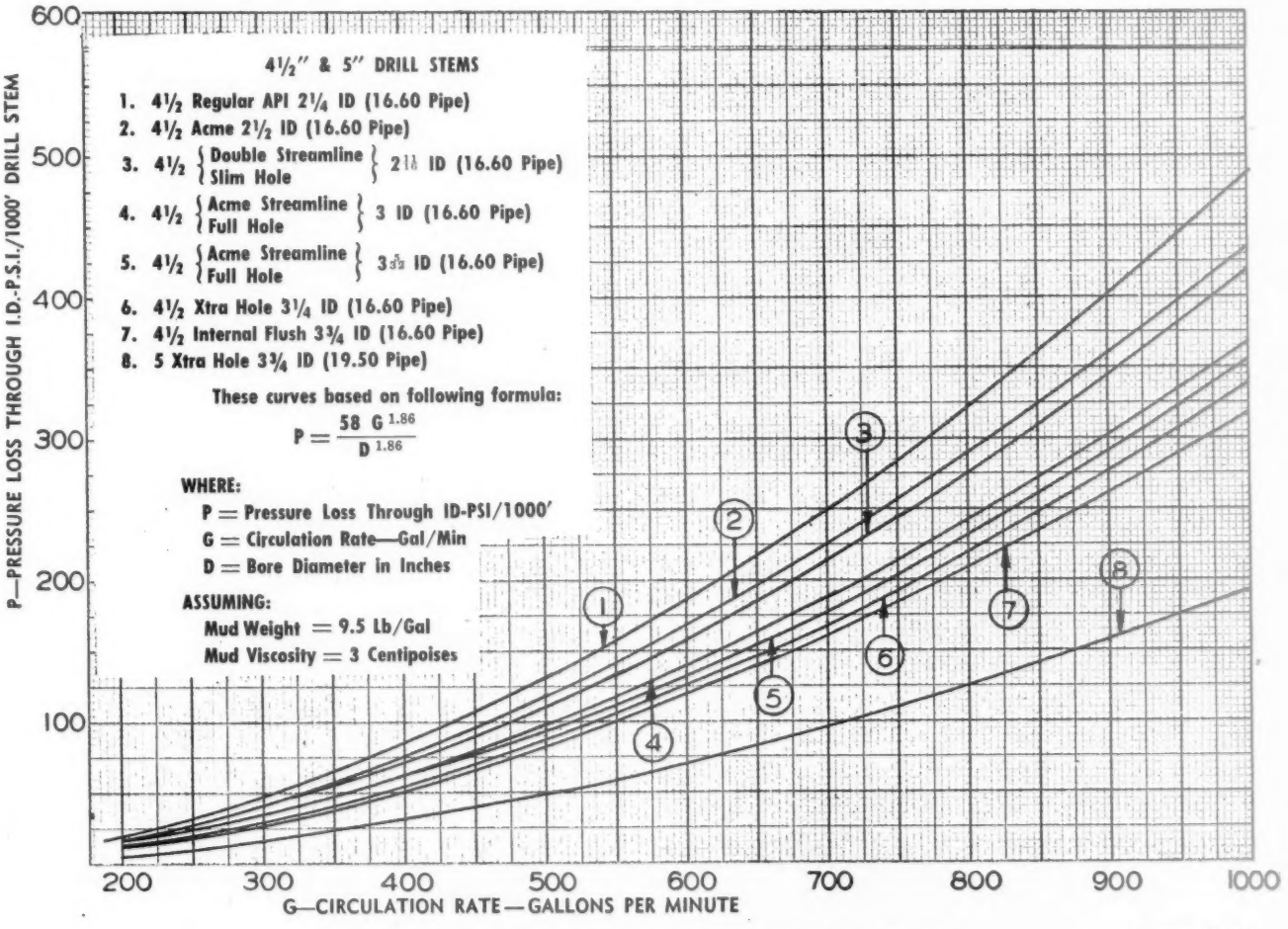

FIG. 15. Friction losses through inside of drill stem vs circulation rate. (Hughes Tool)

this time. The "air lift" which uses compressed air to force the liquid to flow in opposition to its total head is sometimes used. Pumps may be connected in series or in parallel operation to advantage in certain situations. New applications of old and new types of pumps may be expected as the technique of drilling wells progresses.

Prime Movers

The prime mover or device which provides the power for pumping is sometimes used to classify pumps.

The types of prime movers encountered are:

Reciprocating Engines—This includes steam engines, diesel engines, and spark ignition engines. Natural gas or LPG engines are also being used.

Electric Motors—Electric rigs have been used in some localities.

Turbine—On a steam rig any centrifugal pump may be driven by a steam turbine.

Types of Drives

Several schemes are used to couple the prime mover to the pump. These include both direct and indirect drives. Indirect drives include belts (V-belts and flat belts), roller chains, and hydraulic couplings and torque converters. Another paper in this series is devoted to a discussion of types of drives.

Selection of Slush Pumps

Intelligent selection of slush pumps requires a thorough understanding of the power factors involved. Slush pumps are selected on the basis of liner size, length of stroke, and maximum pressure necessary. The horsepower required for circulation depends primarily upon the volume pumped and the pressure required. Factors influencing the pressure are:

1. **Size of drill pipe.**
2. **Changes in annular area.**
3. **Changes in depth.**
4. **Density of fluid pumped.**
5. **Viscosity and gel strength of fluid.**

The volume capacity of a pump depends upon the desired annular return velocity of the drilling fluid as illustrated by the Continuity Equation $Q = AV$. All equations pertaining to selection of pumps have been graphically presented to reduce the work and time in using them. As the velocity of the drilling fluid in the annulus is a function of pipe and hole size, the volume can be determined by using Fig. 14 for any desired return velocity.

After the flow rate has been determined the liner size and pump stroke can be selected for any recommended pump speed by using Fig. 14. With the volume capacity of the pump known, the pressure required to circulate the volume must be obtained in order to determine the horsepower required.

It is necessary to consider the fluid pressure losses throughout the entire circulating system in order to estimate the maximum working pressure to be required by the pump. The greatest pressure drop of the system normally occurs inside the drill column. Fig. 15 can be used to determine the approximate pressure drop in the drill column. This graph is based on a mud weight of 9.5 lb per gal and a mud viscosity of 3 centipoises, thus, a correction must be made for muds with different densities. As pressure loss is directly proportional to mud weight, the correct pressure drop can be obtained by multiplying the pressure drop from the curve by the ratio $\frac{\text{mud density}}{9.5}$.

Generally, the next largest pressure loss occurs across the rock bit nozzles. This is the point where horsepower

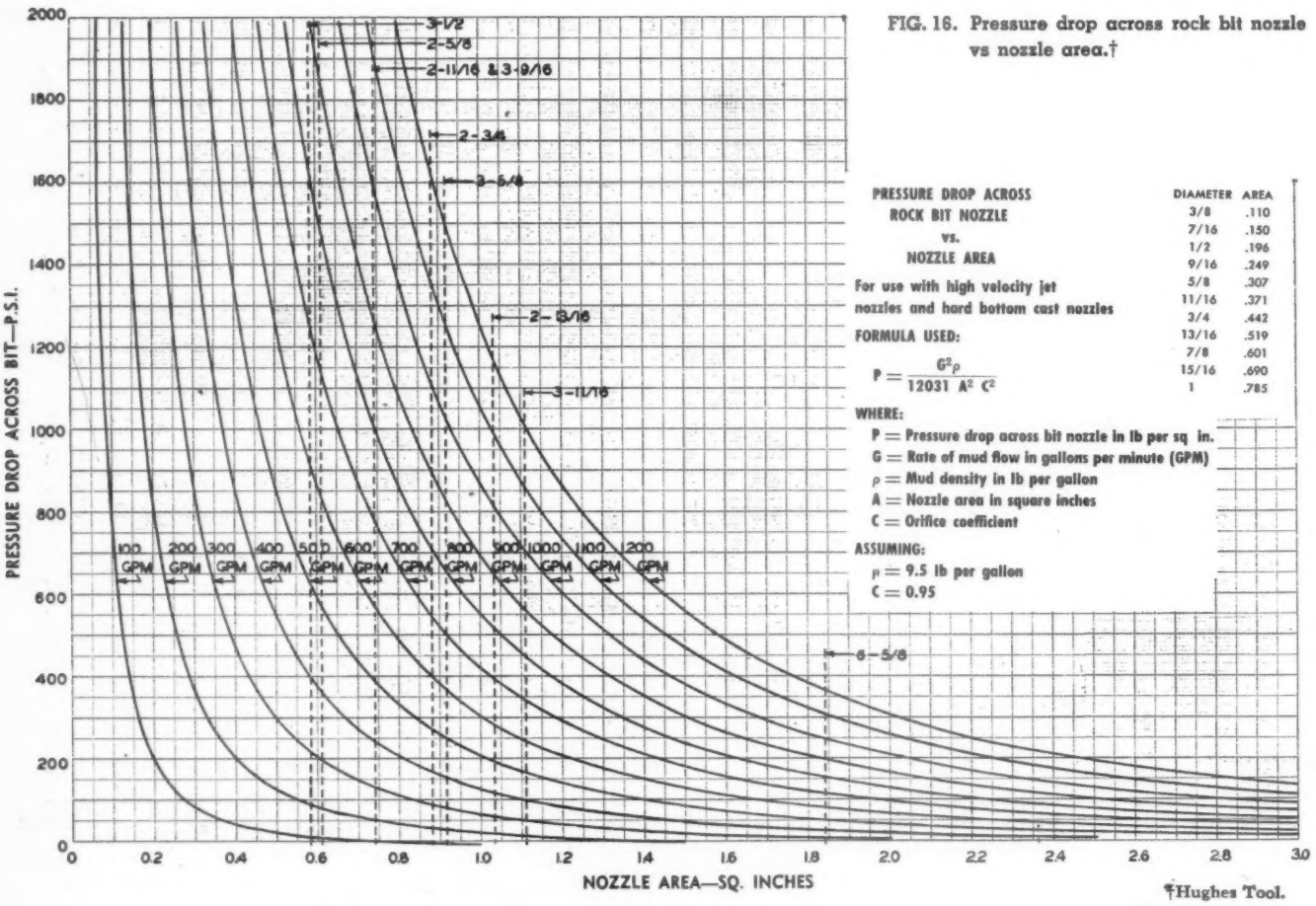

FIG. 16. Pressure drop across rock bit nozzle vs nozzle area.†

†Hughes Tool.

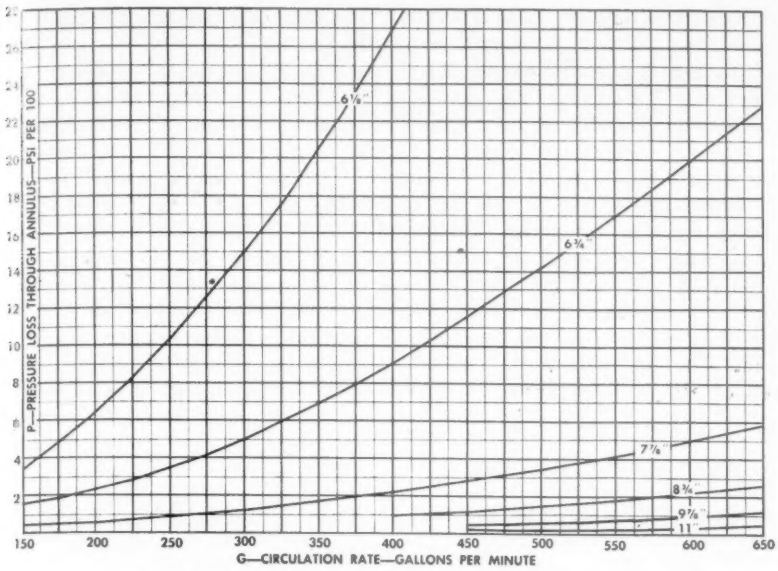

FIG. 17. Friction losses due to fluid return through the annulus.

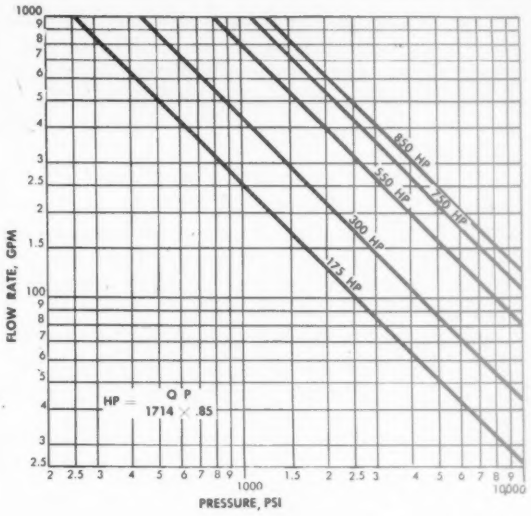

FIG. 18. $HP = \frac{QP}{1714 \times .85}$

can be expended for obtaining higher drilling rates in soft formations. It is now a recognized fact that the most successful rotary rig employs the highest possible hydraulic horsepower at the bit. Unquestionable evidence is available which indicates that increased hydraulic horsepower results in corresponding increases in the drilling rate for soft formations.

Horsepower can be increased at the bit by reducing the nozzle size and hence for the same flow obtain a high jet velocity for jetting the soft formations efficiently. If a minimum of power is available for the bit, the nozzle can be increased to obtain the least possible pressure drop. Fig. 16 can be used to determine the pressure drop across the bit for a given flow rate and nozzle size. The graph was designed for a mud weight of 9.5 lb per gal and must be corrected for muds of different densities.

The pressure loss in the annular space can be determined for the most common hole and drill pipe sizes by using Fig. 17. The pressure loss in the annulus is less than in the drill pipe due to the reduced fluid velocity resulting from a large increase in flow area.

The pressure loss through surface connections depends primarily on flow rate and pipe and rotary hose sizes used on the surface. For a well designed circulating system this loss will not exceed 10 per cent of the total pressure loss in the annular space, drill pipe, and rock bit nozzles.

The horsepower required by the pump assuming an 85 per cent mechanical efficiency will be:

$$HP = \frac{Q \times P}{1714 \times .85} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Where:

Q is required pump capacity, gpm.

P is the total pressure drop in circulating system, psi.

The horsepower may be obtained approximately from Fig. 18 which shows constant horsepower lines for some of the most common pump sizes available.

The largest power driven slush pumps operating today are in the 850 horsepower class or less. Two pumps may be compounded, series or parallel, with proper precautions such as surge dampeners, automatic relief valves, flexible connectors, and pump synchronization. Such pump arrangements, particularly "in series," have offered high horsepower for modern jet drilling programs and provide good flexibility of operation. A compounding program utilizes existing smaller pump units and can adequately serve the purpose of high horsepower units.

The following conditions are assumed and the above method employed for selecting a suitable slush pump:

Size of drill pipe	4½ in. FH 3 in. ID
Size of hole	9⅞ in.
Depth of hole	6000 ft
Desired annulus velocity	180 ft per min
Mud density	10.5 lb per gal
Bit nozzle size and number of nozzles	3 ⅝-in.

From Fig. 14, the pump volume capacity must be 575 gpm in order to have an annular velocity of 180 ft per min in a 9⅞-in. hole with 4½-in. drill pipe. Using this volume in Fig. 14 and assuming an average of 60 strokes per min, a pump with a 7¼-in. liner size and a 14-in. stroke is required.

The pressure drop in the drill pipe would be 128 psi per 1000 ft (Fig. 15) or 768 psi for 6000 ft. Correcting this pressure drop for difference of mud density the corrected pressure would be 768 x 10.5/9.5 = 851 psi. From Fig. 16, the pressure drop through the three ⅝-in. jet bit nozzles would be 335 psi or 369 psi corrected for 10.5 lb per gal mud. Fig. 17 shows the pressure loss in the annulus space for 575 gpm to be 0.9 psi per 100 ft or 54 psi for 6000 ft of hole. Correcting for the 10.5 lb per gal mud results in 59.5 psi pressure loss. The pressure loss in the hole is therefore 851 + 369 + 59.5 or 1279.5 psi and assuming a 10 per cent loss in the surface connections, the total loss in the circulating system would be 1407 psi.

The horsepower requirement from Fig. 18 would be approximately 553 and would necessitate a 600 hp pump or an equivalent series arrangement.

It should be realized that in hard rock drilling where conventional type bits rather than jet bits are used, a good reduction can be made in horsepower requirements. Assuming three 1-in. nozzles with port area openings of 3 (.785) = 2.36 sq in., Fig. 16 shows a pressure drop of 35 × 10.5/9.5 = 38.7 psi rather than 369 psi for the three ⅝-in. jet nozzles. This increase in nozzle size results in a calculated horsepower savings of 533 — 423 = 130 hp.

The above method of analysis should prove valuable for estimating slush pump size requirements and is considered reasonably accurate for selection purposes. For more precise selection the pressure loss through and around the drill collar must be considered.

Installation and Maintenance

Installation. Pumps which are improperly installed and put into service cannot be expected to perform satisfac-

torily. Many maintenance troubles can be traced back to the time when the pump was put in service. Sometimes the difficulties are obviously due to improper installation while in other cases, such as bearing life, the troubles may not show up for quite some time and their cause is not easily determinable.

In general, pumps should be situated as closely as possible to the fluid source in order to decrease the suction head. Ample space must be provided around the pump for inspection, lubrication, and repair. It is very important that the pump be leveled and attached securely to its foundation.

All the piping to the pump should be independently supported to avoid unnecessary strain. Inlet piping should be as direct as possible, of large diameter, and free of air pockets. Manufacturers' recommendations should be followed as closely as possible.

Maintenance. A preventive maintenance program of periodic inspection and replacement of worn parts is the best insurance against shutdown at inconvenient times. Particular attention should be given to use of the correct liner size for the pumping conditions which prevail. Bearing life can be cut drastically with only small overloads on the pump. The pump must be kept properly lubricated and stuffing boxes examined daily. The liquid valves should be inspected frequently to see that excessive wear has not cut their efficiency.

Even the best preventive maintenance program cannot eliminate all troubles. Given below is an outline of some of the more common pump troubles and their causes.

PUMP TROUBLES AND THEIR CAUSES

Slush pump troubles and causes

1. Failure to deliver liquids:
   a. Lift too high
   b. Air or vapor pocket in suction lines
   c. Pump not up to rated speed
   d. Valves or packing leaking
   e. Pump not primed.
2. Pump does not deliver rated capacity:
   a. Air or vapor pocket in suction line
   b. Pump not up to rated speed
   c. Pump not filling (because of heavy high gravity fluids)
   d. Mechanical defects: (1) Valves not seating; (2) Packing worn; (3) Liner scored; (4) Wrong spring tension in suction valves.
3. Pump does not develop rated discharge pressure:
   a. Gas or vapor in liquid
   b. Pump not up to rated speed
   c. Pump not filling from suction line because of high gravity fluid
   d. Mechanical defects: (1) Valves leaking; (2) Piston packing worn; (3) Liner scored; (4) Internal leakage resulting from defect gasket on liner (Piston type reciprocating pump only).
4. Pump loses liquid after starting:
   a. Suction line not filled with liquid
   b. Gas or vapor in liquid
   c. Air or vapor pockets in suction line
5. Pump overloads driver:
   a. Pressure higher than that for which pump is rated
   b. Specific gravity of liquid being pumped is too high
   c. Oversize liners and pistons
   d. Mechanical defects: (1) Bearing too tight; (2) Misalignment; (3) Pinion shaft bent; (4) Packing too tight.
6. Vibration:
   a. Starved suction—(1) Suction pressure too low; (2) Gas or vapor in liquid; (3) High gravity or congealed fluid.
   b. Misalignment
   c. Worn or loose bearings
   d. Shaft bent
   e. Foundation not rigid
7. Stuffing boxes overheat:
   a. Packing too tight
   b. Packing not lubricated
   c. Wrong grade of packing
   d. Box improperly packed
8. Bearings overheat:
   a. Obstruction in lube oil line
   b. Improper grade of oil
   c. Dirt in bearing
   d. Bearing adjusted too tight
   e. Dirt in oil
   f. Oil feed pump not pumping
   g. Moisture in oil
   h. Misalignment
   i. Oil level low
9. Bearings wear rapidly:
   a. Misalignment
   b. Shaft bent
   c. Vibration
   d. Lack of lubrication
   e. Bearings improperly installed
   f. Dirt in bearings
   g. Moisture in oil

Centrifugal pump troubles and causes

1. Failure to deliver liquid:
   a. Pump not primed
   b. Air or vapor pocket in suction lines
   c. Pump not up to rated speed
2. Pump does not deliver rated capacity:
   a. Wrong direction of rotation
   b. Air or vapor pocket in suction line
   c. Pump not up to rated speed
   d. Viscosity of fluid greater than that for which pump was designed
   e. Mechanical defects: (1) Wear rings worn; (2) Impeller damaged; (3) Internal leakage resulting from defective gaskets.
3. Pump does not develop rated discharge pressure:
   a. Wrong direction of rotation
   b. Gas or vapor in liquid
   c. Pump not up to rated speed
   d. Viscosity of liquid greater than that for which pump was designed
   e. Mechanical defects: (1) Wear rings worn; (2) Impeller damaged; (3) Internal leakage resulting from defective gasket.
4. Pump loses liquid after starting:
   a. Suction line not filled with liquid
   b. Gas or vapor in liquid
   c. Air or vapor pockets in suction line
5. Pump overloads driver:
   a. Speed too high
   b. Total head lower than rated head
   c. Specific gravity of liquid being pumped is too high
   d. Viscosity of liquid different from that for which pump is rated
   e. Mechanical defects: (1) Misalignment; (2) Shaft bent; (3) Rotating element dragging; (4) Packing too tight.
6. Vibration:
   a. Starved suction—(1) Suction pressure too low; (2) Gas or vapor in liquid; (3) Gas or vapor pockets in suction line.
   b. Misalignment
   c. Worn or loose bearings
   d. Rotor out of balance: (1) Impeller plugged with foreign matter; (2) Impeller damaged.
   e. Shaft bent
   f. Foundation not rigid
7. Stuffing boxes overheat:
   a. Packing too tight
   b. Packing not lubricated
   c. Wrong grade of packing
   d. Insufficient cooling water to jackets
   e. Box improperly packed
8. Bearings overheat:
   a. Oil level low
   b. Improper grade of oil
   c. Dirt in bearings
   d. Dirt in oil
   e. Moisture in oil
   f. Insufficient circulation of cooling water.

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FORMATION TESTING

C. V. Kirkpatrick*

DESPITE the recent advances in formation evaluation techniques, there still remain many doubtful pay zones that are penetrated by the drill. The commercial potential of some of these zones can only be evlauated by drillstem test. It should be noted at the outset, that a "negative" test does not always prove the formation to be non-commercial. This fact, notwithstanding, the technique of drillstem testing is the most positive method for evaluating the producing potential of a reservoir.

There are several major items of information that can be obtained from a properly conducted drillstem test.

1. The test will evaluate the formation's ability to produce fluid.
2. A sample of the formation fluid may be obtained at the time of the test.
3. An indication of the producing capacity of the reservoir is obtained.
4. The shut-in and flowing bottom hole pressures are recorded.
5. The hydrostatic pressure exerted by the mud column is recorded.
6. A formation suspected of taking mud can be checked.
7. The effectiveness of a casing cement job may be checked.
8. A graphic pressure vs time record of the condition of the well bore and well flow performance is recorded for purpose of analyzing results of the test.

This subject is to be developed under the following major headings: The Principle of Formation Testing, Types of Test, Testing Tools, Planning the Test Program, Testing Technique, and Pressure Chart Analysis.

The Principal of Formation Testing

The basic principle of drillstem testing is illustrated in Fig. 1. Empty drill pipe, carrying a rubber packer mounted directly above a perforated section of anchor pipe, is lowered to the bottom of the well. The packer is extended to block off the annular space between the drill pipe and the wall of the well bore. A valve in the drill stem is then opened to complete the communication between the perforated anchor pipe and the empty drill pipe. The test zone is thus relieved of the hydrostatic pressure of the mud column and any fluid in the formation is then free to flow up through the drill pipe. After the test period, the equalizing valve is opened in order to equalize the pressure across the packer, so that it may be pulled more readily. The test fluid remaining in the drill stem is then reversed out and the tool is pulled.

Types of Test

Types of tests and testing tools vary according to the testing conditions. Principal difference is in the packers used and their location with respect to the formation being tested. The different conventional tests are as follows: 1. Single wall packer test, 2. Double wall or straddle packer test, 3. Cone packer test, 4. Wall over-cone packer test, 5. Casing packer test.

The first four tests listed refer to "open-hole" tests.

In the single wall packer test (Fig. 1), the packer diameter is usually 1 in. less than the bit diameter when used in a full gage hole. If the packer is to seal in a core hole, the packer diameter is approximately ½ in. less than the core bit diameter. The packer is set by means of weight transferred to the anchor pipe which rests on the bottom of the hole or on a cement plug spotted specifically for test purposes. Special tools are now available that eliminate the anchor pipe in the open hole test.

The double wall or straddle packer test is most commonly used in the full gage open hole (Fig. 2). There are two reasons for this type of test. First, where the depth and pressure make the additional support and seal of a second packer desirable; secondly, where a test zone is to be isolated. In the latter case, the blank adaptor between the two packers is replaced by a perforated adaptor and the perforated tail pipe is replaced by blank tail pipe. Arrangements may be such that both the pressure between the two packers and the pressure below the bottom packer may be obtained or just the pressure in between the two packers.

The cone packer is used when the core hole is smaller than the hole above (Fig. 3). In this case, the anchor pipe

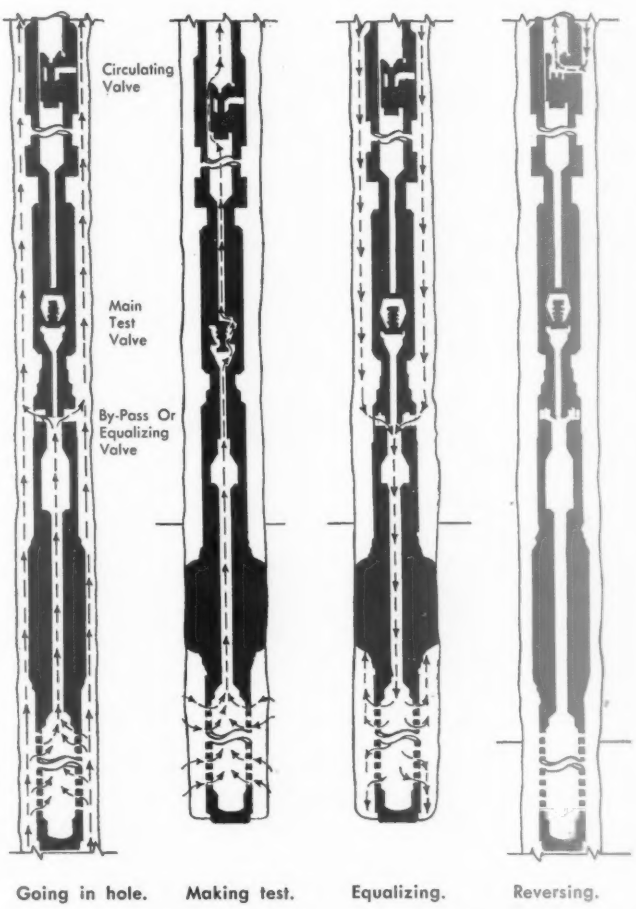

FIG. 1. Diagram illustrating the basic principle of drillstem testing. Pressure recording element is usually located in the anchor pipe assembly.

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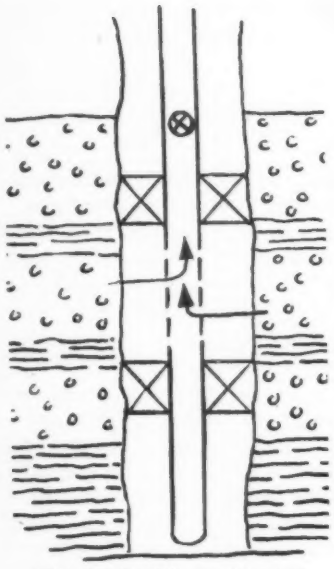

FIG. 2. Straddle packer test.

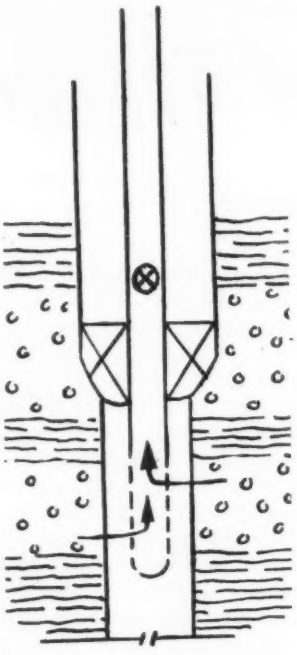

FIG. 3. Cone packer test.

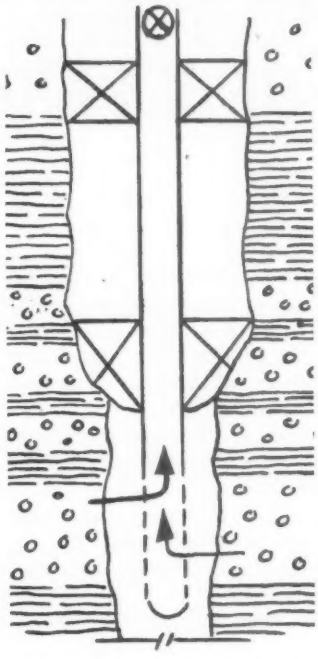

FIG. 4. Wall over cone packer test.

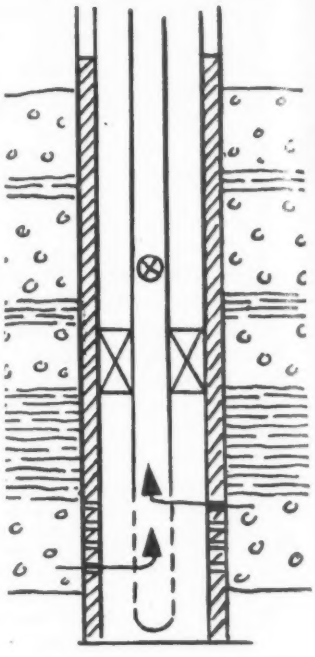

FIG. 5. Testing through perforations in the casing.

does not rest on the bottom of the hole. The seal is obtained by forcing the tapered packer into the upper end of the core hole. The force for seating the packer is the combination of drill pipe and mud column weight. The shoulder for seating must be in a firm formation.

The wall over cone packer test is used when the core hole shoulder is soft or unconsolidated and the additional seal of the wall packer is desirable. (Fig. 4).

The casing packer (hook-wall packer) is used for testing through perforations in the casing, for productivity in the open hole below the casing, or to test for water shut-off after cementing (Fig. 5). As the anchor pipe does not rest on the bottom of the hole, the hookwall packer can be released and reset at any desired level in the casing. Zones may be isolated and tested through the use of straddle packers in this technique.

Testing Tools

Aside from the different packer combinations, there are certain test tools and tool components that are necessary for the test to be carried to satisfactory completion. Fig. 1 illustrates the various components that make up the complete drillstem test tool.

In the conventional test tool, there are three and sometimes four valves, the packer (or packers), the perforated anchor pipe, and the pressure recorder. The valves are designated as the by-pass or equalizing valve, the main test valve, the circulating valve, and in one arrangement a fourth valve is included. This is a disc type valve, which is located in the upper part of the tester and serves several purposes. First it insures against a possible contamination of the test fluid; secondly, leaks in the drill pipe above the test zone can be detected; finally, it enables an initial shut-in pressure to be obtained. It is opened by dropping a go-devil down the drill stem to shear the metal alloy disc. It may be placed either above or below the water cushion. A heavier go-devil must be used if it is placed below the cushion. One or more pressure recorders are included in the tool make up. Often times, a sample chamber is included, if it is desired to obtain a sample of the formation fluid.

The by-pass valve opens a fluid passage way through the bore of the packer to connect the annular space above the packer to the annular space below. This equalizes the fluid pressure across the packer thus facilitating the seating and unseating operation. It further reduces the swabbing tendency of the packer when coming out of the hole. A by-pass choke may be used for the purpose of controlling the flow of fluids from the formation during the drillstem test.

The main test valve is one that is opened after the packer has been set. During trips, the tester valve may be locked by a J-slot arrangement. To unlock the valve and open it, weight must be applied to the slip joint, the drill pipe must be rotated slightly, and lowered several inches. The valve may be closed in position again by raising the drill pipe a few inches. This can be accomplished without disturbing the sealed packer or opening the by-pass. A recently developed tool accomplishes the valve opening and closing sequence by means of a hydraulic cylinder, spring, and drill pipe weight.

The circulating valve permits circulation of oil and gas samples from the well by either reverse or normal circulation before the tool is removed from the well. The two principal advantages to be gained by use of this circulating valve are (1) the drilling fluid may be reconditioned with the tool still in the hole, (2) the removal of a fire hazard which would otherwise exist, if combustible fluids were dumped on the drilling rig floor. That is, the complete sample remaining in the drill pipe can be circulated out and the pipe pulled dry.

The pressure gage records all pressures that enter the perforated anchor pipe during the complete test, from the time the tool enters the surface casing until it returns to the rig floor and is dismantled. Recording is essentially a plot of pressure versus time. Several recording pressure gages (up to three) may be used depending on type of test.

A safety joint is often used immediately above the packer. This safety joint will permit unscrewing the rest of the apparatus from the packer if the packer becomes stuck in the hole.

Planning the Test Program

It is significant to note that in certain sections of the Gulf Coast open hole drillstem tests are rarely run. The geological province will usually provide an index as to the suitability of the zone for open hole test. Aside from oper-

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ating policy, there are several reasons for this condition. Certain sections of the Eocene-Wilcox and the deep Frio formation are hard on packers in open hole tests. These sections are tight and have slow pressure build-up characteristics. This means, a large pressure differential across the packer for a longer period of time and, consequently, a high percentage of packer failures. The down-dip Frio (Corpus Christi area) is characterized by thin sands with many shale breaks. Packer seats are unsuitable in this type of formation and consequently, the tests usually are of the cased hole type. The three principal objections to open hole testing are: First, the limitations of open hole packers; secondly, the frequent lack of a properly planned program to include complete well preparation prior to testing and the third is the objection to open hole testing at depth, as the record shows increasing failures with depth. In certain areas, many companies, as a matter of operating policy, will open hole test only down to a specified depth.

As stated before, however, the suitability for open hole testing will vary with the geological province. The Low Salinity Wilcox and the Rio Grande Valley Frio are very well suited for open hole testing. The Cockfield-Yegua trend also falls in this category. The limestone zones of South and West Texas are commonly open hole tested.

Certain operators make extensive use of "rat-hole" drilling. Cores will be taken in the rat hole, the zone tested if core shows are favorable, and the rat hole is then reamed out, with the process repeated until contract depth is reached. This policy will allow rather safe testing in otherwise troublesome areas, but is obviously an expensive procedure. Operators, who as a matter of policy, core extensively will likewise open hole test frequently.

When the work program for a well is planned, selection of a hole diameter favorable to testing should be the first consideration. The best packer seat should be selected that can be found immediately above the producing zone. Generally, the harder formations such as sandstone, lime, and chert provide the best packer seats. They are firm and do not wash out to oversized diameters during drilling.

A short section test usually gives more conclusive information than a test over a long section.

When long sections are being tested, it should be remembered that the drilling mud in the hole must be produced into the drill pipe before the formation fluid can enter. If the volume of the mud is large, a sizable back pressure may result when the mud is extended in a column up the bore of the drill pipe. Testing long sections with small diameter pipe or tubing should be avoided because of the increased back pressure effect.

Testing Technique

Before discussing specific techniques, it is well to recall a few fundamental factors that are operative during the test procedure.

The packer supports the downward force of the mud in the annulus. This can represent a considerable shock load when the test valve is first opened. The magnitude of the shock is dependent upon the size of the valve opening and the pressure inside of the pipe. The use of chokes and water-cushions in the drill pipe tend to reduce shock loads. One special test tool is specifically designed to ease the shock loads normally present in the conventional testers. A "dry-test" is the worst mechanical condition encountered in testing. It is evident that the smaller the packer area exposed to the pressure differential, the better chance the packer will have of holding. This is, of course, a point in favor of rat-hole testing. On the other hand, the pressure exerted by the mud column helps facilitate the effectiveness of the packer seal.

In the conventional single wall packer, open hole test, the anchor pipe must support the packer from below and carry the combined downward forces of the drill pipe and mud column. Although the friction between the packer and the wall of the well bore helps support a portion of this load, the amount of help is indeterminate.

The drill pipe above the packer is subjected to a collapsing pressure imposed by the hydrostatic pressure of the mud. This consideration should be a principal governing factor in determining the amount of water-cushion to be used in the test.

Hole Conditioning. Proper conditioning of the hole and the drilling fluid prior to running the tester is most essential for successful testing. It has been estimated that fully 50 per cent of mechanical test failures have been due to improper conditioning of the hole. A full gage clean hole is important. If the testing tool has to be spudded through tight places, mud cake and debris will be pushed to the bottom of the hole where they will tend to clog the perforated tail pipe when the tester is open.

The drilling mud should have sufficient weight to control the formation pressure and a low viscosity is generally desirable. Before coming out of the hole to take a formation test, circulation should be maintained long enough to clean the hole completely of cuttings, cavings, and viscous mud.

Testing Packer Setting. Once the mud and hole are in proper condition, the tester is assembled on the drill pipe and lowered into the well with the by-pass valve open and the tester valve closed. (Fig. 1). During the trip into the well, the fluid level in the annulus should be observed from time to time to see if any leaks develop in the equipment. The observations must be made while the pipe is stationary. A drop in the fluid level may indicate a leak in the drill pipe or tester.

The annulus should be full before the packer seal is made and before the tester is opened. If a sudden drop in the fluid level occurs when the valve is opened, the tool should be picked up immediately to close the test valve, because the packer has failed to seal and the mud is entering the drill pipe from the annulus above the packer. Failure to quickly close the tool may result in lost control of the well.

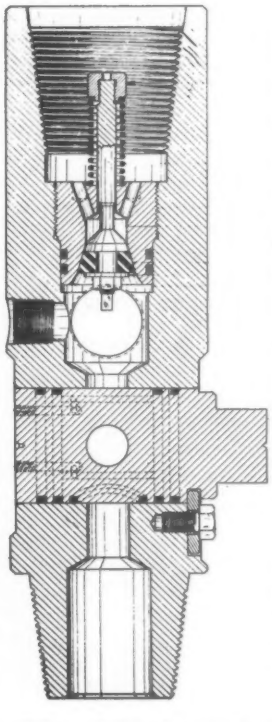


FIG. 6. API surface control head assembly.

Surface Control Equipment. Surface control equipment is attached to the upper end of the drill pipe before the tester valve is opened. (Fig. 6). This equipment will usually consist of a control head with a conductor pipe leading into a slush pit or a storage tank. A small outlet valve with a rubber hose attached is sometimes used to bubble air or gas through a pail of water, in order to detect light blows. The control head itself contains two valves arranged in tandem with an outlet between them for attaching the flow line. The kelly may be connected to the control head any time circulation down the drill pipe is required. A control head and chokes in the flow line are essential to control formations which flow under considerable pressure.

Time of Test. The length of the period of test in the open hole often times is limited by company policy. Fear of a stuck

packer is the principal reason for short tests. Twenty to thirty minutes appears to be the usual length of time for flow tests in the Gulf Coast area. This time, of course, depends upon the the experience that has been gained from the area under test. In the Mid-Continent, the length of test may run one hour or more. The danger of losing the hole is not nearly so great here as in the Gulf Coast plus the fact that the formations being tested are usually more consolidated and of a lower permeability and hence require a longer build up time.

No restrictive time limit is placed on the cased hole test.

When the flow has continued for the desired length of time, the tester valve is closed. The first few inches of upward travel of the drill pipe closes the tester valve, but does not open the by-pass valve or unseat the packer. (Fig. 1). The tool is left in this position to allow the pressure below the packer to reach equilibrium with the formation pressure surrounding the well bore. The shut-in pressure is recorded. If the initial shut-in pressure is desired, it may be obtained by use of the disc valve as previously noted.

Trip Out Of The Hole. At the completion of the shut-in period, the by-pass valve is open and the packer is unseated. During the trip out of the well with the testing tool, it is essential to keep the hole full of mud, otherwise the level in the well may drop to the point of losing control of the formation. Any fluid that has entered the drill pipe through the tester valve, and has not emerged at the surface, is trapped above the valve and is usually brought to the surface with the drill pipe. Emptying the drill pipe of volatile fluids as each stand is unscrewed, is a fire hazard and should be conducted with caution.

The circulating valve mentioned earlier offers a method for removing the sample from the drill pipe before the pipe is pulled from the hole. Once the valve opens, it locks to permit circulation in either direction through the drill pipe and the annulus. Thus the sample may be reverse circulated through the drill pipe and gaged as it flows from the pipe.

Circulation of samples from the drill pipe using the circulating valve has certain possible disadvantages to be considered. Pumping out through the annulus leads to a certain amount of liquid mud contamination and gas cutting. Reverse circulation up the drill pipe increases the mud pressure on the exposed formation in the open hole. In most combinations of pipe and hole sizes, the pressure drops in the annulus is less than that in the drill pipe. Reverse circulating may therefore result in breaking down weak formations.

Special Testing Tools. Many efforts have been made to improve the existing conventional testing tools. There is as yet no tool available for testing close to bottom in the open hole that has the ruggedness, simplicity, and reliability of the standard testing tools now in use. Certain tools have been developed, however, that have a special application and should be mentioned.

One major oil company has developed a wireline drillstem tester that does not require removing the drill pipe from the hole between the coring operation and the bottom hole formation test.

One of the service companies now offers a retrievable wireline tester for testing in a small core hole ahead of the bit without removing the drill pipe after coring or before the testing operation.

The above tools differ from the conventional wall packer testers by a common feature, in that only a small sample of the formation fluid is obtained. A pressure build-up curve, shut-in pressure, and a fluid sample are obtained.

The most widespread application for the above two testing tools is in areas where the wireline core barrel is in common use. The procedure of coring and testing can be repeated any number of times without removing the drill pipe from the well.

A multi-zone open hole tester that does away with the anchor pipe is now offered by one of the service companies. The anchoring device utilizes nine mechanically retractable "dogs". The anchoring mechanism does not support the full weight but only enough to allow the packer to take hold.

Pressure Chart Analysis

Proper evaluation of drillstem tests results can only be obtained through the use of pressure chart analysis. Dependence upon the visual observation of the formation fluids is often times grossly misleading. Many instances are of record in which strong fluid shows proved to be non-commercial. Also many instances have been noted, where apparent "dry tests" were determined to be commercially productive by analysis of the pressure chart and the analysis was born out upon completion of the well. Valid results of tests can only be assured through the proper interpretation of these charts. A thorough knowledge of the basic testing tools and the mechanics of the test operation is essential for this analysis. The chart is no panacea. There is no absolute value of flowing pressure for example, that will enable a positive decision to be made as to whether or not a given zone will be commercially productive. It is, however, the relative rate of build-up that is the characteristically important criterion.

It is desirable to always have at least two pressure re-

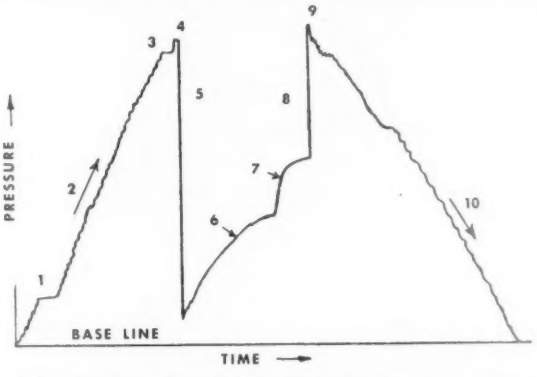


FIG. 7. Chart illustrating fundamental pressure recordings (flowing well test).

1. Putting water cushion in drill pipe
2. Running in hole
3. Hydrostatic pressure (weight of mud column)
4. Squeeze created by setting packer
5. Opened tester, releasing pressure below packer
6. Flow period, test zone producing into drill pipe
7. Shut in pressure, tester closed immediately above packer
8. Equalizing hydrostatic pressure below packer
9. Released packer
10. Pulling out of hole

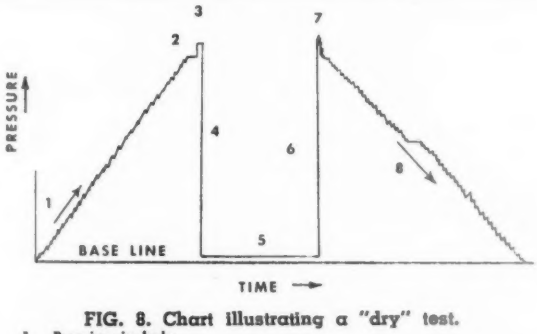


FIG. 8. Chart illustrating a "dry" test.

1. Running in hole
2. Hydrostatic pressure (weight of mud column)
3. Squeeze created by setting packer
4. Opened tester, releasing pressure below packer
5. Flow period, test zone open to atmosphere
6. Closed tester and equalizing hyd. pressure below packer
7. Pulled packer loose
8. Pulling out of hole

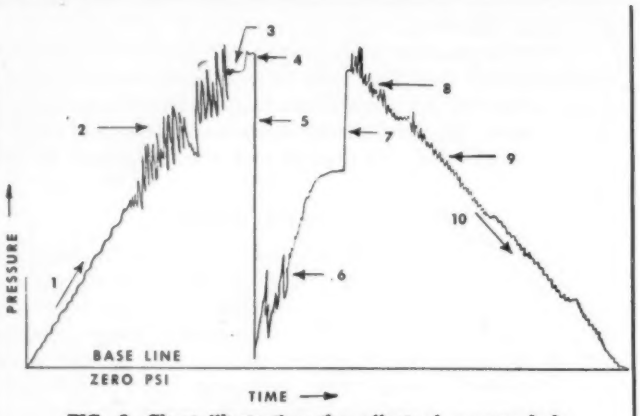
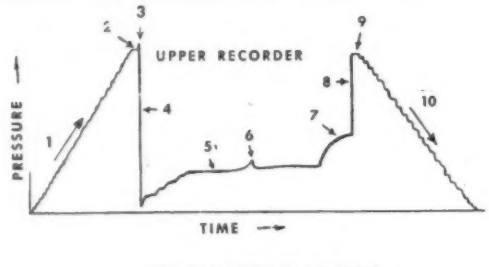


FIG. 9. Chart illustrating the effect of a poor hole condition.

1. Running in hole
2. Indicates bad hole condition, scraping wall cake
3. Hydrostatic pressure (weight of mud column)
4. Squeeze created by setting packer
5. Opened tester, releasing pressure below packer
6. Indicates plugging of perf. anchor or tester
7. Closed tester and equalizing hyd. pressure below packer
8. Indicates swabbing due to bad hole condition
9. Indicates less swabbing, better hole condition
10. Pulling out of hole



TESTING BETWEEN PACKERS

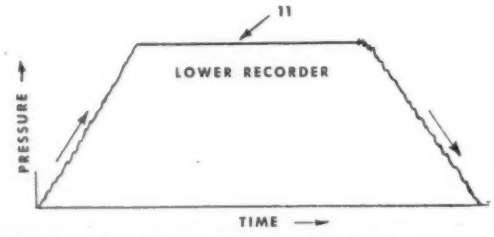


FIG. 10. Chart illustrating a straddle packer test.

1. Running in hole
2. Hydrostatic pressure (weight of mud column)
3. Set packer
4. Opened tester, releasing pressure between packers
5. Test zone flowing
6. Rise in pressure due to closing in to change chokes
7. Shut in bottom hole pressure
8. Equalizing hydrostatic pressure between packers
9. Hyd. pressure at conclusion of test
10. Pulling out of hole
11. Lower recorder, below bottom packer shows no drop in pressure, proves bottom packer is holding

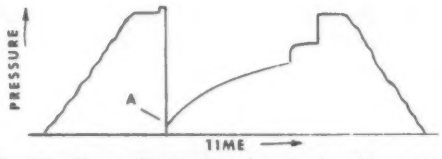


FIG. 11. Chart illustrating inertia in the pressure recorder.

It will be noted from point A on the chart above that the pressure line indicating the opening of the tool, coincides with the start of the build-up in flow pressure. The exact initial flow pressure point cannot be determined. This condition is caused by the successive pressure events happening too rapidly to allow the clock to turn the chart and separate the lines.

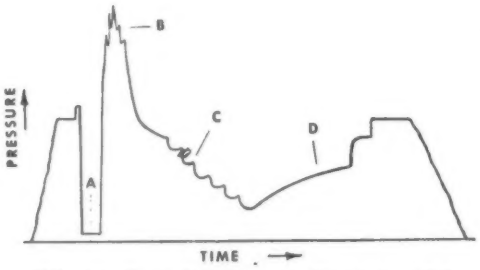


FIG. 12. Chart illustrating a "treated well."

A — Initial flow pressure before treatment.
B — The pressures at this point are caused by the filling of the pipe with treating fluid, and the pumping of the fluid into the formation.
C — These points denote swabbing of the well.
D — This portion of the curve reflects the flowing pressure build-up.

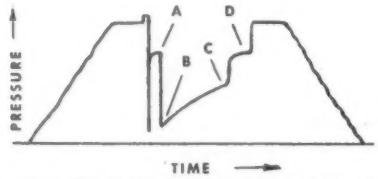


FIG. 13. Chart illustrating both initial and final build-up pressures.

A — Initial shut-in pressure build-up.
B — Opening of the test tool.
C — Final flowing pressure build-up.
D — Final shut-in pressure build-up.

corders and sometimes three when testing. One to be placed in the flow stream; a second to be placed immediately below the tester perforations, blanked off from the tester flow string; a third recorder is desirable when straddle testing.

Pressure recorders are of various types all of comparable accuracy. The chart is essentially a recording of pressure versus time. The absolute value of pressure, as reflected by the chart, is determined by use of a calibration constant which denotes so many psi per unit deflection away from a base line. For example, in one recording unit, a vertical deflection of 1 in. represents 1000 lb per square inch. Special formulas are used for the extrapolation of build up pressures.

Certain fundamental chart recordings are presented in order to set out the basic problems of chart interpretation. These are followed by more detailed chart recordings wherein most drillstem testing problems are represented and analyzed.

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* * *

SAFETY

J. Thurman Green*

WITH the current trend toward greater drilling depths and the extra heavy equipment for rotary drilling, plus all the allied equipment that goes with a rotary rig, the rig owner has a sizeable sum invested in equipment. To realize a fair return on his investment, it is necessary that he exercise extreme caution and care in the operation and maintenance of the rig and its allied equipment.

In order to do this, a well trained crew of operators is essential and their safety is of utmost importance. Personal injuries as a rule are the result of an unplanned event. Oftentimes they necessitate a rig being shut down for the care of the injured. At other times accidents may occur that cause great damage to equipment, even though there are no personal injuries. A well organized and planned safey program keeps accidents at a minimum.

When personal accidents do occur, they should be given immediate first aid treatment and where necessary medical aid should be available at all rig locations. Some members of the drilling crew should be trained as first aid administrators.

Burns

In present day drilling techniques artificial muds play an important part in drilling and it is quite natural that employees will come in contact with various kinds of chemicals, some of which cause burns to the skin. In event of chemical burns of any kind, large amounts of fresh water will help to dilute the chemical and lessen the severity of the burn. In event of chemical burns, or fire burns, when the first aid treatment is complete the burned area should be covered with dry bandages and the patient placed in the care of a docor.

Fire extinguishers of an approved type should be situated in convenient spots around the rig location for possible fire control, and all reasonable precautions with reference to open fires should be taken. Heating stoves should be properly vented and should be located where gas from the well will not be a risk. During the time of drillstem tests, smoking should not be permitted and all fires in stoves, regardless of the type stoves, should be extinguished.

Testing equipment should be available for use in sour crude areas where hydrogen-sulphide gas is a safety hazard. No crew member should go where hydrogen-sulphide gas is suspected without respiratory equipment and safety belt and life lines.

Personal Protective Equipment

Each member of the drilling crew should take advantage of personal protective equipment for his own welfare. The employee should always use goggles when doing any type of work that would possibly cause injury to the eyes.

He should wear close-fitting clothing and dress according to the season, with reference to temperature. Clothing should be kept clean by frequent washing. He should wear shirts with long sleeves at all times as a protection against sun burn, insect bites, poison ivy, small scratches, and flash burns.

Short, tight-fitting gloves only should be worn and an approved skull guard and hard-toed shoes are necessities for the protection of the rig worker.

*Safety director, Sun Pipe Line Company.

Tools and Equipment

Good housekeeping is a prerequisite on any drilling location. Where all equipment and tools are kept in good clean working condition, the employee naturally takes more interest in his work. There should be a definite place for each type of tool and equipment used. All hand tools should be placed on a tool board for convenience and kept in a good state of repair. All other pieces of equipment, generally found on a rig floor, such as subs, bits, etc., should have a designated place where they would not be stumbling hazards to the employee.

Break-out tongs should be well balanced and the counterbalance for these tongs should be below the derrick floor on a guide placed in the corner of the derrick and at a height not to hamper operations on the floor.

Electrical tools and lamps should be equipped with three-wire, grounded type cords.

It is necessary at times to use some solvents to keep tools clean. Gasoline should never be used for this purpose.

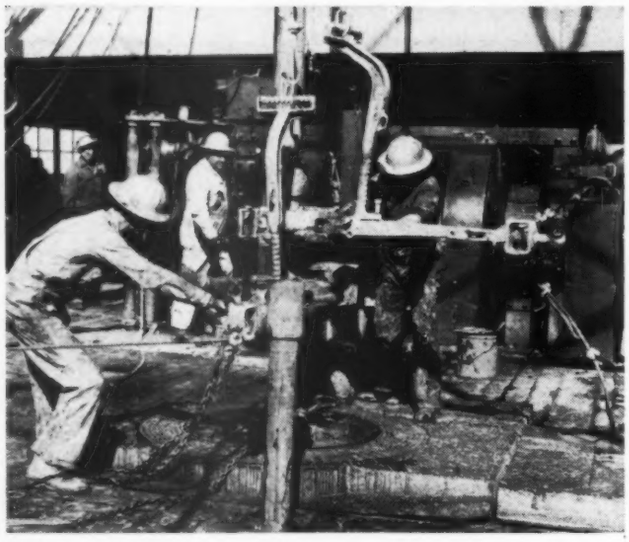
A number of rig owners have used various color codes in keeping equipment and machinery neat. A well-planned color code on equipment and machinery is a great aid to the employee.

The Derrick

Capacity of the derrick should be equal to, or greater than, specification IV of API Standard No. 4, "Specifications for Standard Rigs, Derricks, and Accessory Equipment," with regard to the proposed depth of the well, or any other factors.

Wind velocity might influence the anticipated load. Precautions should be made to prevent the derrick from turning over as a result of wind. This can be done by the use of guy wires, and/or proper construction of the derrick foundation. Telescoping and jack-knife masts should be guyed in accordance with generally recognized safe prac-

For their personal protection workmen wear long-sleeved clothing that is reasonably close fitting, steel-toed safety shoes, helmets, and gloves.



Breakout tongs should have a strong safety tail-line adequately secured by wireline clamps.

tices in the industry, and in compliance with manufacturer's specifications.

Crown blocks should be landed during daylight hours and should be properly fastened to the water table. All working platforms on derricks should be securely fastened and derrickmen should wear safety belts and belly bands with approved tail lines while working anywhere in the derrick.

An auxiliary means of escape from the derrick and masts should be provided. This is usually in the form of a wire line running from the stabbing board to a spot removed from the derrick, and the lines should be provided with the proper mechanical slides. A 1-in. manila rope with an attached slide is permissable, but in the case of rope or wire lines, it should be properly maintained so that the slide could always work free.

Traveling blocks should be strung next to the working board and the fast line kept away from the working board. All sheaves of the traveling block should be guarded properly with heavy metal to prevent the derrickman's hands from being drawn into the block.

The derrick floor should be guarded on all areas, except those openings for stairways or for bringing pipe or other material onto the derrick floor. A toeboard to prevent loose material from rolling off the derrick floor should be installed. All steps leading to the derrick floor should have hand rails and be set level to avoid slanting steps.

Boiler, Engines, Draw Works

Regardless of the type prime movers used on the drilling rigs, there are certain safety factors that must be considered. Where boilers are used, the boiler should be equipped with the proper water-indicating devices and should always be placed so that neither end is toward the derrick. Operation of the boiler should be under the constant supervision of the fireman. Soft plugs should be placed at least 1½ in. above the inside of the crown sheet.

Every steam engine used as a prime mover should be equipped with a bleeder pipe at least 1-in. in diameter. On internal combustion engines the radiator fans and drive belts should be guarded. Around the draw works there are certain pieces of equipment that should always be guarded, such as open sprockets, any type of drive shafts, chains, etc.

All keys should have a guard placed over them, or should be driven in close so as not to catch any loose clothing of the operator. Emergency stop devices should be provided for each prime mover for drilling machinery. There are a number of devices suitable, but from the API's *Safe Practices in Drilling Operations,* Manual No. 10, the following is suggested:

1. *For a steam engine: a quick-closing valve, independent of the throttle valve, installed in the steam line as close as is feasible to the engine.*
2. *For an internal-combustion gas engine: an ignition or grounding switch.*
3. *For a diesel engine: a quick-closing valve or equivalent device that will shut off the air to the engine's air-intake manifold and prevent entry of gas-laden air, or a means of releasing the engine compression in such a manner that an open flame or spark will be produced.*
4. *For an electrical motor: a suitable switch in the motor circuit, or a switch or stop button in the control circuit—approved for the location in which it is installed.*

It is recommended where possible that the rig floor be built up flush to the top of the rotary table. However, some prefer to have the rotary table elevated; especially when power slips are not used. In such cases, the rotary should always be enclosed by a heavy guard.

Tools should be kept clean and arranged in an orderly manner on the tool board. Good housekeeping of this kind makes the crew readily aware of missing tools or the necessity for additional ones. Note the specific location of first-aid kit and goggles.

When catheads or catlines are being used for any reason, the driller should remain at his post while another person operates the cathead. When not in use, catlines should be hung in a convenient place and not allowed to lie on the floor with the possibility of getting caught in some machinery or of being stumbled over.

Backup tongs should be snubbed to the substructure and the snubbing lines should be of the same strength as the breaking lines. These lines and their attachments should be watched closely for any possible wear. When the tongs are not in use they should be hooked back in the corner of the derrick, so that they can not swing and cause possible injury to employees.

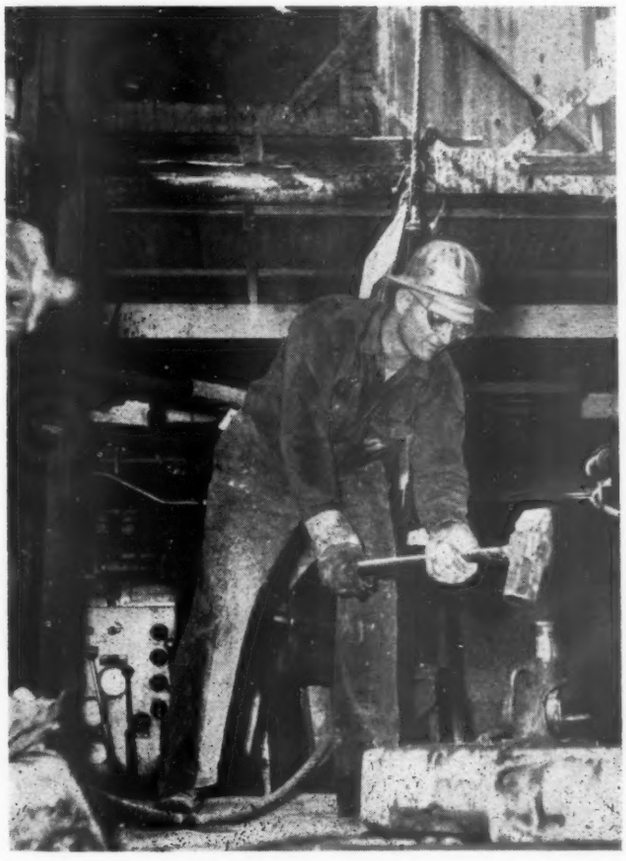
Power tongs should be equipped with snubbing lines similar to those used for conventional tongs. Weight indicators should be used on every drilling rig; kept in a good state of repair, and as accurate as possible. This is of great importance to the driller.

Sub-Floor and Outside Equipment

Blowout preventers are not required on some rigs, depending on the nature of the field, but when required there are certain factors that should be given consideration. The blowout preventer should be securely fastened in place and tested periodically to assure its proper functioning. It should be of a remote control type with controls located where they can be operated at ground level as well as from the derrick floor. The area around the controls should be kept clear so they may be reached in any emergency. All employees should be schooled in the line operations.

There is a possibility at times that the mud pump may develop pressure in excess of safe working pressure for it or its accessory equipment, so the pump should be equipped with a pressure-relieving device. This may be a spring-loaded safety valve, or a shear-pin safety valve, or a rupture disk. There should be no stop valves between the pump and its pressure-relieving device.

Any time steel strikes steel flying particles are possible and eyes should be protected.



Drill stem tests should be made during daylight hours.

Exhaust from steam pumps, boilers, or internal-combustion pump engines should be discharged in such a manner as not to hamper workmen in any way, or hinder their vision of the various operating equipment, material, or debris, to prevent stumbling hazards.

Drilling locations are not always ideal spots with reference to terrain, and it is quite possible that pipe racks may be near the ground on one side and several feet from the ground on the other. The operator should always know the amount of pipe and weight the pipe racks will be expected to take care of. Each pipe rack should safely support all pipe stored on it. Bumper blocks should be installed on the walkway opposite the pipe rack to prevent pipe from rolling off the walkway.

Change rooms, dog houses, or other small buildings containing materials should be well lighted and situated in an area where it is normally safe to smoke. They should not be in front of or to the rear of the boilers. Where heating is necessary, an approved type stove should be provided and well ventilated.

There are many working techniques in handling drilling equipment, which are too numerous to mention in detail, but such practices are known to experienced drillers or drilling foremen. This is one of the main reasons it is necessary to have frequent crew meetings to explain any abnormal event that may occur at a drilling location and to indoctrinate the new employee in the performance of his work.

Coordination of each man's job is necessary for effective job performance and it should be the duty of each person in the crew to be alert always to excessive pressure and tension in various rig equipment.

Cooperation With Services

Service companies will have some of their equipment on location for various uses, and here again is a responsibility for the driller, or the drilling foreman. They need to coordinate their efforts with those of the service companies' supervisors for the welfare of all concerned.

Cementing jobs may be done at night, and casing may be run at night, but it is strongly advised that drill stem tests should be made in daylight hours only.

General safety education, by means of periodic meetings, employer house organs, safety magazines and other educational data are necessary in the proper use and maintenance of all equipment and tools. When labor turnover is not excessive, instructions and indoctrination practices are most advantageous.

ECONOMICS OF MORE EFFICIENT SLIM HOLE DRILLING—NO. 1

CUT COST PER FOOT BY INCLUDING "BLUE DEMONS" IN YOUR SLIM HOLE PROGRAM

The major slim hole drilling advantage is economic. Reduced drilling costs per foot can result from efficient use of smaller equipment and crews . . . a lower investment, with savings in labor, rig-up, travel, fuel and maintenance.

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Size and Orientation of Vug in Limestone Cores

A method for mathematically predicting the arrangements of vugs to improve the accuracy of core analysis permeability and porosity predictions is suggested

ADRIAN E. SCHEIDEGGER

A STRIKING feature of many Alberta oil fields is that they contain large numbers of cavities in the form of vugs and fractures. It is especially the vugs which have played havoc with the conventional methods of core analysis on small plugs so that one had to resort to the analysis of full diameter cores in order to get more or less reliable values for porosity and permeability. The values obtained, however, for permeability and porosity even from such large cores are often not satisfactory. The reason for this is that the permeability and porosity measured on a core plug is not representative for the effective permeability and porosity of this type of rock. Rather, the measurements are conditioned by the particular arrangement of the vugs in the particular plug.

In practice, it will always be possible to get only relatively small core plugs. For relevant measurements of the effective porosity and permeability of vuggy rock, however, one should have a block which is large compared with the vugs, say about a cubic yard or so. The particular arrangement of the vugs in the smaller samples will be the chief determinant of the measured value of porosity and permeability. As it is impossible to get such large samples, the problem is to deduce as good values as possible from smaller ones.

It has been shown earlier by the author (1) that in principle the effective permeability of a piece of rock can be determined if the matrix permeability and the form and arrangement of the vugs are known. Vice versa, one can also find the matrix permeability of a piece of rock if the effective permeability and the shape and size of the vugs are known. Hence, the effective permeability of a piece of rock shaped differently from the specific core plug under investigation could be determined. The crucial point is to find a method to determine the distribution and shape of the vugs from the analysis of core plugs.

In this matter, Waring and Layer (2) have made an important contribution. They suggested that by measuring the area of the cross-section of the vugs at the end of the plug, a quantitative measure for the volume of void space could be obtained. Thus, if the ends of a core plug are traced, and if the cross-sectional areas of the vugs showing at those ends are planimetered, then the percentage of the total area of the ends taken up by vugs, is equal to the percentage of void volume in that core plug. Naturally, if intermediate sections of the plug are also planimetered the value for the void volume becomes more accurate. It has also been considered by Waring and Layer that vertical sections of a core plug might be prepared, but the conclusion is that the vertical sections have no particular advantage over the horizontal sections other than that of providing more areas to work with.

Waring and Layer did not proceed to classify the vugs into big ones and small ones; all they were interested in was the total amount of void space due to vugs and crevices. For a fruitful application to permeability estimates, however, it is obvious that more information is required. One should know something about the direction of the vugs and their size.

The Author

Dr. A. E. Scheidegger is a member of the research department of Imperial Oil Ltd., Calgary, Alberta, Canada. He was born in Switzerland and received his undergraduate training in physics at the Swiss Federal Polytechnic Institute in Zurich. He won a Swiss-Canadia Students Exchange Fellowship that enabled him to take his Ph.D. in applied mathematics at the University of Toronto. Subsequently he was on the staff of Queen's University in Kingston, Ontario, for two years teaching physics to engineering students. He joined Imperial two years ago.

Collecting the Data

Given a core plug, the most ideal description of the vugs would obviously be obtained if one were able to list all regions of void space by giving them a set of geometric co-ordinates (say x, y, z) whose corresponding point falls into that void space. It is also quite obvious that it is not feasible to do this, first, because it is not known what is inside a core plug without cutting it into very small pieces. This would require a tremendous amount of labor, and second because the information thus gained would be of such a complex nature as to be useless for further investigation.

Therefore, it will be necessary to try some simpler method like that of Waring and Layer[2]. As their method seems workable for what they proposed, all that is required is to extend it so that some additional information will be obtained.

It is therefore proposed to take tracings of the ends of a core plug as was done by Waring and Layer; but, in addition, the side of the plug should also be traced. This is done by wrapping transparent paper around the core plug and taking the tracings in this manner. The area of each vug showing is noted and the results grouped into ranges. Thus one will obtain a distribution function of void area with respect to cross-sectional area showing at the surfaces of the plug. Separate records are to be taken for the end and the side of the core.

For a sensible evalution, it will be indicated to calculate the relative area of the vugs with respect to the total area traced. Thus one will arrive at a distribution function f(A) which indicates what fraction of the total area traced is contained in vugs that show a cross-sectional area larger than A. From this function, the differential vug size distribution function $\alpha(A)$ can be calculated (approximately) by the relation

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EXCLUSIVE

$$\alpha(\bar{A}) = -\frac{f(A_2) - f(A_1)}{A_2 - A_1}$$

where

$$\bar{A} = (A_2 + A_1)/2.$$

One also has the relation

$$f(A) = \int_{\delta}^{\infty} \alpha(A)\, dA.$$

If desired, one can introduce as argument an "equivalent diameter" x instead of A, that is the diameter of a circle which has the area A; thus

$$x = (4A/\pi)^{1/2}$$

Finally, all the values taken from the tracings of a core may be arranged in tabular form and graphs of the functions f(A) and $\alpha(A)$ may be plotted.

Evaluation

The task is to explain the shape of the cross-sections of the vugs showing in the tracings in terms of the shape and the size of the vugs themselves and to devise a means to infer the latter from the former.

One must assume that the distribution of the vugs in the oil rocks can be represented by some probability distribution function. As the only quantities that can possibly be determined (unless oriented cores are taken) are the size of the vugs expressed by their normal cross-sectional area A_n and the angle of their inclination with the vertical, denoted by θ, the distribution function sought will be $P(A_n, \theta)$, expressing that the porosity due to vugs falling in the range A_n, $A_n + dA_n$ and θ, $\theta + d\theta$, will be $P(A_n, \theta)\, dA_n\, d\theta$. The total vug porosity P_v is, naturally, the integral of $P(A_n\theta)$ over the whole domain.

$$P_v = \int\int P(A_n, \theta)\, dA_n\, d\theta$$

If one has one vug whose characteristics be A_n, θ, then its cross sectional area A_f that is seen at the end of the plug is, from elementary geometry

$$A_f = A_n/\cos\theta$$

The formula expressing the cross-sectional area on the side of the core of such a vug is not so simple. If Φ denotes the angle between the projection of the vug on a horizontal plane and the tangent plane to the core at the point of intersection with the center of the vug, the visible cross-sectional area A_s of each vug on the side of the core will be:

$$A_s = A_n/(\sin\Phi \sin\theta).$$

As for a given value of θ it is entirely fortuitous at which angle Φ the side of the core will intersect the vug, all sizes of cross-sections greater than $A_n/\sin\theta$ may be seen.

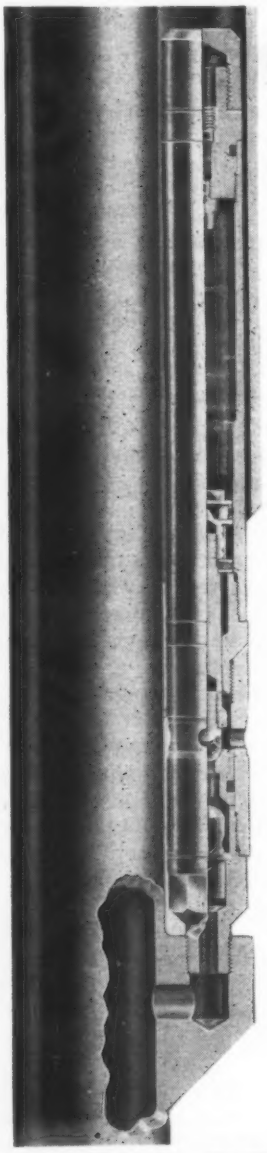
If the vugs are thought of as a whole bundle with a porosity P_v, the fraction of total void space on the area traced will always be equal to P_v notwithstanding at which angle the intersecting plane lies.

Therefore, if it were known that there is only one type of vugs, all inclined at the same angle toward the vertical, the normal cross-sectional area and this angle could be found at once from the distribution curves $\alpha(A)$ for end and side of the core. Obviously, at the end α would be equal to a δ-function for $A = A_n/\cos\theta$:

$$\alpha_f = P_v\, \delta(A - A_n/\cos\theta);$$

and at the side α would be zero for $A < A_n/\sin\theta$, jump to a high value for $A = A_n/\sin\theta$ and then tail out towards zero for $A \to \infty$. Thus, the maxima of $\alpha(A)$ would be at $A_n/\cos\theta$ and $A_n/\sin\theta$ for end and side respectively. From the position of the two maxima, the angle θ and the normal cross-section A_n could be calculated.

The statement that the maximum of the α_s-curve will be for $A = A_n/\sin\theta$ needs some mathematical corroboration. Actually, the distribution function $\alpha_s(A)$ can be exactly calculated in the case considered above when A_n and θ are certain definite values. In this case.



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A will depend on Φ as follows

$$A = \frac{A_n}{\sin \Phi \sin \theta}$$

The probability $\alpha_s(A)\, dA$ that the cross-section of the vug falls into an area range between A and $A + dA$ is proportional to the interval $d\Phi$ which corresponds to this areal range since all values of Φ are equally probable. The latter can be calculated as follows:

$$dA = \frac{A_n}{\sin^2 \Phi \sin \theta} \cos \Phi \, d\Phi;$$

thus

$$d\Phi = \frac{dA}{A(A^2 \sin^2 \theta / A_n^2 - 1)^{1/2}}.$$

Since one has

$$\alpha_s(A)\, dA = C\, d\Phi,$$

one obtains

$$\alpha_s(A) = \frac{C}{A\left(\frac{A^2}{A_n^2}\sin^2 \theta - 1\right)^{1/2}}.$$

The constant C can be determined from the condition that the integral of α_s taken over the whole domain of variation of A must be equal to the vug-porosity P_v:

$$P_v = \int \alpha_s(A)\, dA$$

$$= \int \frac{C}{A\sqrt{\frac{A^2}{A_n^2}\sin^2 \theta - 1}} dA$$

$$= C \int \frac{A_n / \sin \theta}{A \sqrt{A^2 - A_n^2 / \sin^2 \theta}} dA$$

$$= C(\text{arc cos } [A_n/(A \sin \theta)])\Big|_{A_n/\sin \theta}^{\infty}$$

$$= \frac{\pi}{2} C.$$

The differential vug size distribution function at the side of the core is thus:

$$\alpha_s(A) = \frac{2P_v}{\pi A\left(\frac{A^2}{A_n^2}\sin^2 \theta - 1\right)^{1/2}} \text{ for } A > \frac{A_n}{\sin \theta}$$

$$= \text{zero for } A < \frac{A_n}{\sin \theta}$$

It has obviously a maximum for $A = A_n / \sin \theta$.

If one proceeds to study vug distribution where not all the vugs have the same size and direction, but are distributed according to the function $P(A_n, \theta)$ as outlined above, one can write at once, because of the superposition principle:

$$\alpha_f(A) = \int\int P(A_n, \theta)\, \delta\left(A - \frac{A_n}{\cos \theta}\right) dA_n \, d\theta$$

$$\alpha_s(A) = \int\int P(A_n, \theta) \times \frac{2}{\pi\left(\frac{A^2}{A_n^2}\sin^2 \theta - 1\right)^{1/2}} dA_n \, d\theta$$

In principle, the above equations can also be reversed: If α_s and α_f are known, $P(A_n\, \theta)$ can be calculated. This, however, means that one has to solve the above equations with respect to P, or that one has to solve a system of two integral equations. This is rather an involved operation, especially in view of the fact that α_f and α_s are only empirically determined functions. An actual evaluation of P from the tracings of a core would therefore be extremely laborious: It could be accomplished by stepwise approximation methods only.

It is therefore indicated that one should try to get a simpler measure for the arrangements of the vugs. This can indeed be done if it is assumed that $P(A_n, \theta)$ is large only in the neighborhood of a certain value for A_n, θ equal to A_n, θ. In that case, α_s has a maximum for $A = A_s$ max. $= A_n / \sin \theta$, and α_f for $A = A_f$ max. $= A_n /$

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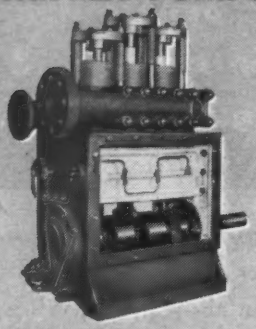

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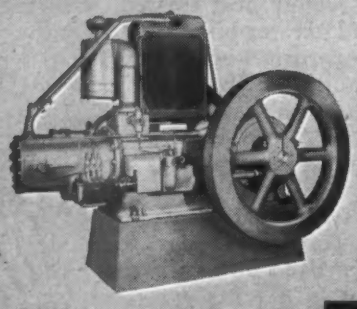

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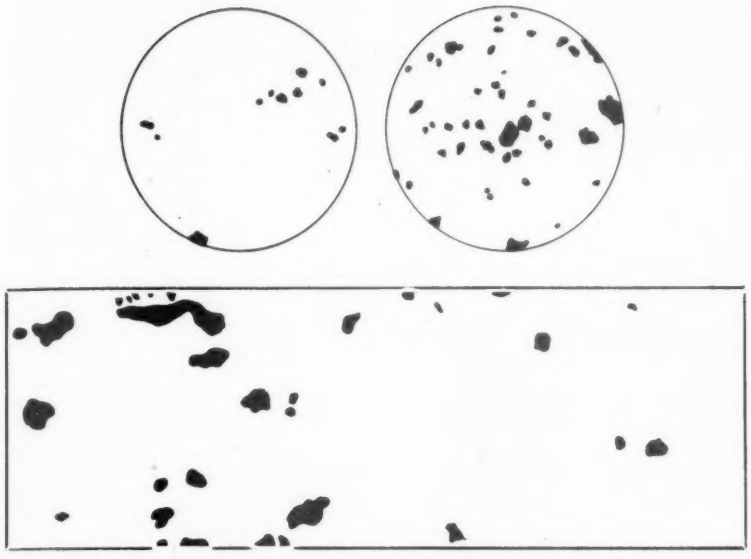

FIG. 1. Tracings of vugs showing at the side and at ends of the core.

$\cos\theta$. The maxima can be easily determined from a graph of $\alpha(A)$ and thus A_f max and A_s max can be found. One has then

$$\tan\bar{\theta} = A_f \text{ max} / A_s \text{ max}$$

and

$$\bar{A}_n = \frac{A_s \text{ max } A_f \text{ max}}{\sqrt{A_s^2 \text{ max} + A_f^2 \text{max}}}.$$

In a general case, the assumption that P is only large for values of the argument in the neighborhood of $\bar{A}$, $\bar{\theta}$, may not be fulfilled. In that case, $\bar{A}_n$, $\bar{\theta}$ can still be calculated according to the formulas above, but they will have the meaning of an equivalent mean angle and cross-section of the vugs. Thus, in the extreme case for instance where all the vugs are directionally evenly distributed, the curves representing α_s and α_f must be identical. In that case, θ would come out as equal to 45 deg which, indeed, has the same effect on the flow in the radial as in the vertical directions.

In practice, it will be noted that the vug size distribution function $f_s(A)$ for the side is usually larger than the vug size distribution function $f_f(A)$ for the end. This may seem inconsistent with earlier remarks, where it was stated that $f_s(A)$ as well as $f_f(A)$ should become equal to P_v for small A's. It should be kept in mind, however, that one will see more vugs on the side than at the end, because some of the smaller ones are bound to be intersected at a very favorable angle. Thus, it is somewhat difficult to make the distinction between "vugs" and "pores" on the side, as the smallest (linear) "pores" will occasionally give sizable intersections with the side of the core, even if they were oriented in one direction only. Thus, "the vug-porosity" should be determined from the end of the core where it can be exactly stated (given an orientation θ) which is to be the dividing line between "pore" and "vug."

As an illustration, a sample determination of the vug sizes using actual core data will now be presented. The core plug used is core 83 from Imperial Amelia Well No. 84 in the Redwater Field, Alberta. The routine data of this core are listed in Table 1.

The next task is to take the tracings of the vugs that are showing at the side and at the ends of the core on transparent paper. The result of this procedure is reproduced in Fig. 1 (vugs in black). It should be noted however, that Fig. 1 is a reduced reproduction of the original drawings so that measuring Fig. 1 would not give the results obtained.

The areas of the vugs showing on the tracings are to be measured. This can be done either by using a planimeter, or by counting little squares from an overlying grid of millimeter squares. In the present study, the latter method was used. The measured areas were then grouped into ranges, whose boundaries were 1, 2, 4, ... 2^n ... sq mm. The results are tabulated in Table 2; the total area on the ends and that on the side of the cores falling into each range are listed in Column 3 thereof.

TABLE 1. Routine data of core 83, Imperial Amelia well 84 Redwater field, Alberta.

Length	94.36 mm
Diameter	87.66 mm
Area of end	6035 sq mm
Area of side	25986 sq mm,
Porosity	0.156
Permeability	180 md
Description*	B, C, D, 1, 2, 3, 11

* For the code to description, cf. Ref. 3.

The reduced area in each range is obtained by dividing the total area within the range by the total surface of the core that was traced; i.e., by twice the area of the end for the two ends, and by the area of the side for the side. The results thus obtained are listed in Column 4 of Table 2.

Adding up the reduced areas in all ranges containing vugs with a bigger area than a given range boundary, yields the "vug size distribution function" f(A). This function gives one the fraction of volume which is taken up by vugs showing an intersection greater or equal to the range boundary which was chosen. The vug size distribution functions for end (front) and side are plotted in Fig. 2.

Finally, the differential vug size distribution function can be approximately calculated according to the formula in Section 3, by dividing the reduced area in each range by the width of that range. Thus, the last column of Table 2 was obtained, and the differential vug

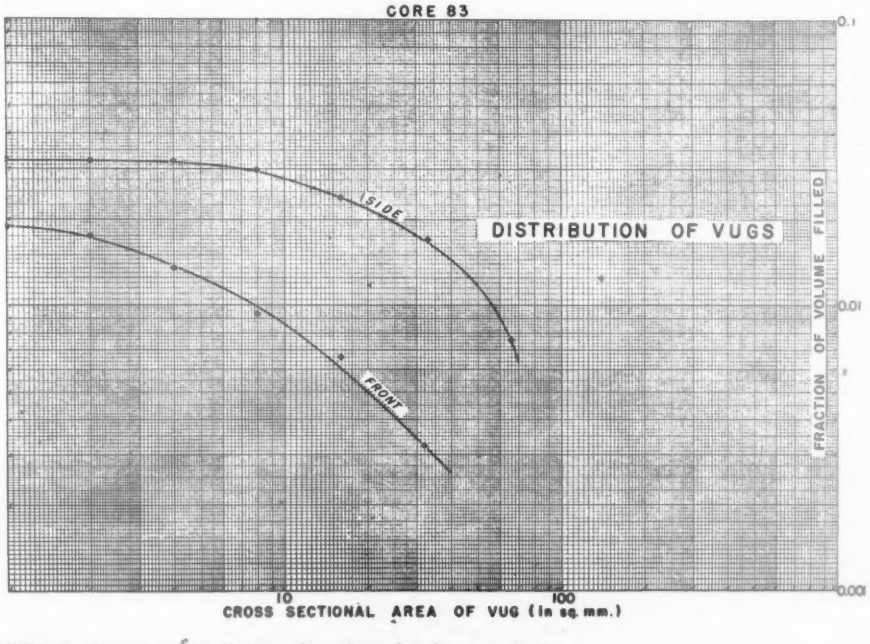

FIG. 2. Vug size distribution functions for front and side.

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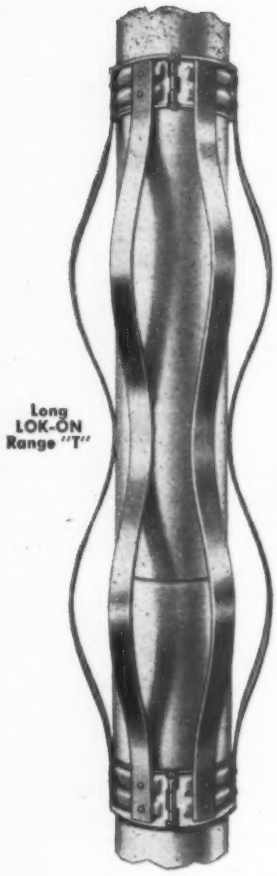

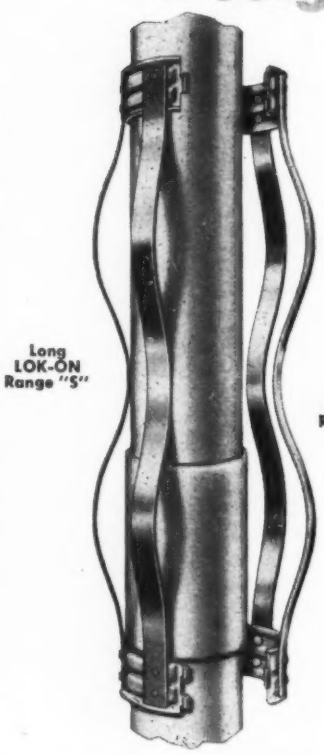

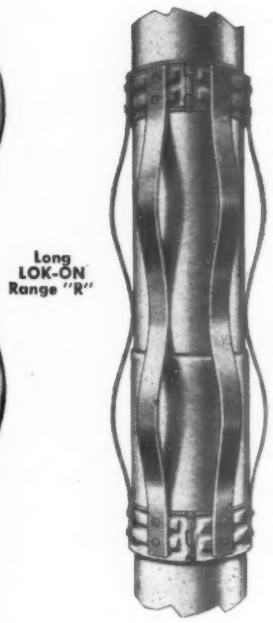

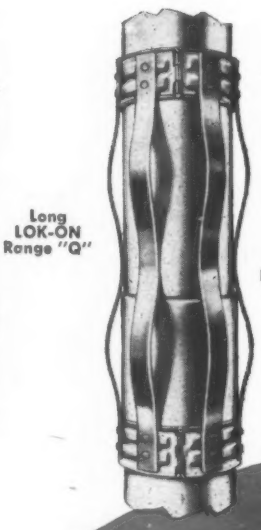

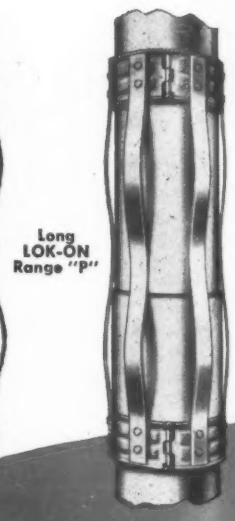

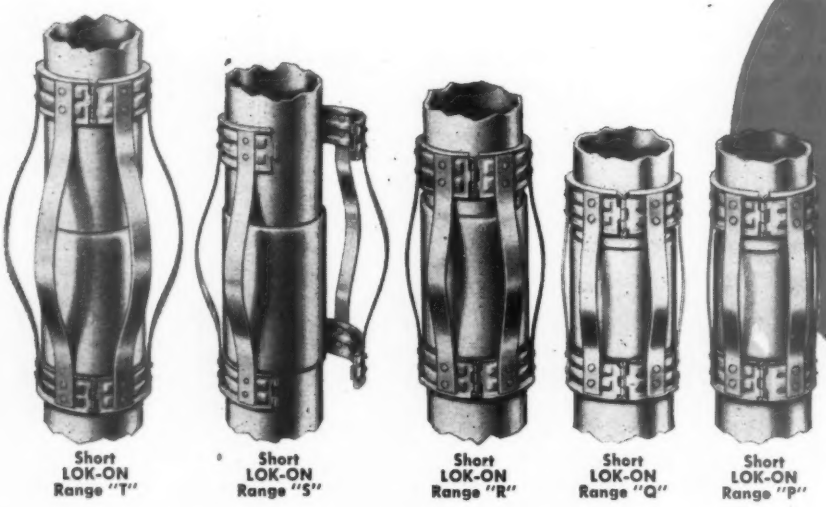

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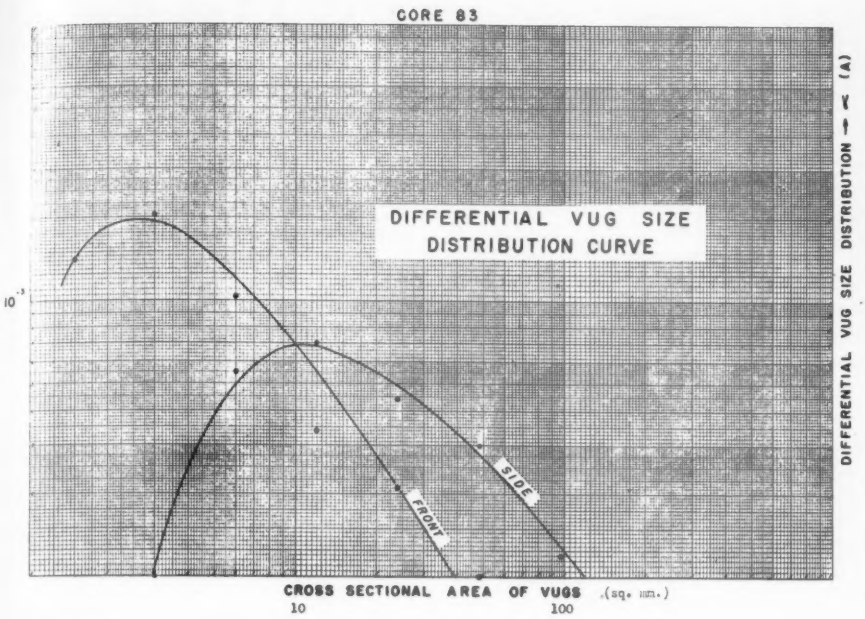

FIG. 3. Differential vug size distribution function curve.

size distribution function can be plotted as shown in Fig. 3.

TABLE 2. Vug data of core 83, Imperial Amelia well 84.

Area of vug (=A) sq mm (range boundary)	Median (=A) (sq mm)	Total area in range (sq mm)	Reduced area in range $\alpha(A)\,dA$	Cumulative reduced area f(A)	Differential vug size distribution function $\alpha(A)$
		Front, area traced 12,070 sq mm			
1				.01896	
	1.5	17	.00141		.00141
2				.01755	
	3.0	49	.00406		.00203
4				.01349	
	6.0	50	.00414		.00104
8				.00935	
	12.0	33	.00273		.00034
16				.00662	
	24.0	41	.00339		.00021
32				.00323	
	48.0	39	.00323		.00010
64				.00000	
		Side, area traced 25,086 sq mm			
1				.03235	
	1.5	1	.00004		.00004
2				.03231	
	3.0	5	.00019		.00010
4				.03212	
	6.0	57	.00219		.00055
8				.02993	
	12.0	145	.00558		.00070
16				.02435	
	24.0	182	.00700		.00044
32				.01735	
	48.0	254	.00977		.00031
64				.00758	
	96.0	197	.00758		.00012
128				.00000	

It is found from the last graph that the maximum of the differential vug size distribution function lies at $A_s = 11$ sq mm for the side, and at $A_f = 2.8$ sq mm for the front. Thus, one finds the final result.

$$\tan\theta = A_{f\,max}/A_{s\,max} = 0.25$$

$$\underline{\theta = 14.0^0}$$

and similarly

$$\underline{\bar{A} = \frac{A_{f\,max}\,A_{s\,max}}{(A_f{}^2{}_{max} + A_s{}^2{}_{max})^{1/2}} = 2.7 \text{ sq mm}}$$

The above discussion can be extended to the calculation of the matrix porosity of the core. As mentioned earlier, the vug volume in the core can be calculated from the limiting value of the vug size distribution function for the fronts of the core. From Table 2, one finds

$$f_s(A = 1) = 0.01896$$

The fraction of volume that is left for the "matrix" is thus 0.98104. The routine porosity of the core is (from Table 1) 0.156, the total void space of a unit volume of the core is thus 0.156. However, the void space of the same volume contained in vugs is 0.01896, the void space contained in the matrix is thus 0.137. Thus the porosity P_m of the matrix is

$$\underline{P_m = 0.137/0.981 = 0.140}$$

Conclusion

It may be stated that one has succeeded in establishing a method to find the size and orientation of the vugs in a limestone core, using only data that can be obtained from an analysis of the surface of the core. Being a statistical method, it is subject to certain limitations. It works best when the vugs are all more or less uniform, and if there are enough of them to enable one to calculate accurately the required distribution functions. The method seems to be applicable for routine analysis of a large number of cores.

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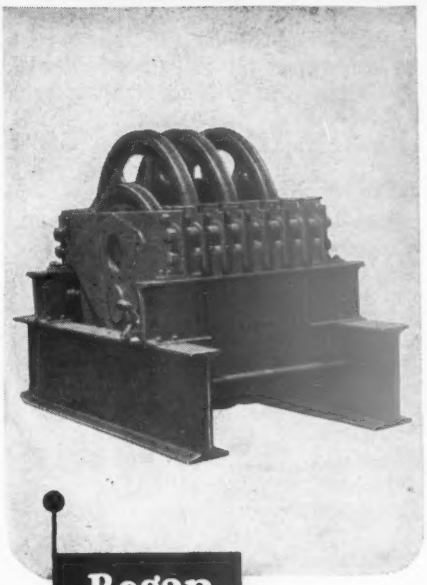

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WHAT'S DOING IN DRILLING

NEBRASKA

★ Ohio Oil Company has an oil discovery in the West Sidney gas field of Cheyenne County. Its No. 2 Shaw is a mile east of the Harper-Turner No. 1 Dimick, a "J" sand oil discovery of last June.

The No. 2 Shaw missed production in the "D" sand and on drillstem test of the "J" sand at 4973-93 ft, recovered 2470 ft of free oil with a good blow of gas; on test at 4994 to 5000 ft there was recovery of 150 ft of oil, 30 ft of mud and 600 ft of salt water.

NEW MEXICO

★ Sinclair has announced the completion of its No. 13 Barber "A," in Lea County. On test the well flowed 824 bbl of 37.2 deg oil a day through an 18/64-in. choke, with gas-oil ratio 1213 to 1.

Production was through perforations at 3 intervals in Padock zone from 5104 to 5194 ft, with turbine pressure of 900 lb. Total depth was 5250 ft, plugged back depth 5197 ft with 7-in. casing set on bottom.

TEXAS

★ Continental Oil has completed 2 more wells on their McCollum and Wiebusch lease in the Wemac field of Andrews County. Its No. 8, TD 13,389 ft, produced 1800 bbl of 50 deg crude daily through a ¾-in. choke from casing perforations 13,298-13,348 ft. GOR was reported at 126 to 1 with flowing tubing pressure at 550 lb. No. 9 was drilled to Ellenberger also and completed through perforations 13,302-13,352 ft. On test it flowed at a rate of 1886 bbl of 49.5 deg oil, GOR 420 to 1.

★ Cities Service has reported dual completion of its joint interest TXL "L" No. 1 in Midland County, Texas, for a rated dual potential of 3815 bbl of oil.

The well, the largest producer in the Virey field, flowed 403 bbl of oil in 6 hours through a 23/64-in. choke from perforations in the Bend Pennsylvanian from 10,333 to 10,358 ft for a rated potential of 1720 bbl daily. Flowing tubing pressure was 2450 lb and the gas-oil ratio 4970 to 1. It also flowed 524 bbl of oil in 6 hours through a ¾-in. choke for a daily potential of 2095 bbl from the Ellenburger in open hole at 13,128 to 13,193 ft. Tubing pressure was 325 lb with a gas-oil ratio of 1191 to 1.

Well is located in sec. 23, block 41, T3s, T and P Survey and is a quarter mile north extension to Pennsylvanian production in the area.

★ Husky Oil Company has dually completed its No. 2 Ellenberger well in the Emma field, Andrews County, Texas, in the Fusselman and Ellenberger formations.

The Fusselman zone was perforated 11,329 ft to 11,343 ft and 11,354 ft to 11,368 ft. On an 8-hour test the well flowed 48 deg oil at the rate of 390 bbl per day with gas-oil ratio 1053 cu ft per bbl. Anticipated allowable from this zone is 275 bbl per day.

The Ellenberger was perforated from 12,270 ft to 12,475 ft and on a 6-hour test flowed 49 deg oil at the rate of 1080 bbl per day with 14/64-in. choke. Gas-oil ratio is 583 cu ft per bbl. Present allowable on the Ellenberger is 350 bbl per day.

PERU

Douglas Oil Company has made its second Peruvian discovery 2 miles NW of its first well. Well is flowing 38 deg crude at a rate of 90 bbl per day through a ¼-in. choke. Location is on the coastal side of the Lobitas area, bottomed at 3266 ft, 1200 ft offshore. Douglas is now preparing to drill a 5000 ft test offshore and ½ mile NW of this latest completion. There is considerable encouragement since Compania Petrolera Lobitas completed a well last July only 1400 ft from the Douglas property, for a productive rate of 530 bbl per day of 39 deg oil. This well was bottomed at 6485 ft and is producing from a 90-ft interval with high gas pressure.

MONTANA

★ The Murphy Corporation et al have another good well in the East Poplar pool of Roosevelt County, northeastern sector of the Williston Basin. Its No. 45 Unit, cored and drilled to 5771 ft in the "C" zone of the Charles formation, flowed at the daily rate of 1224 bbl a day on test from 5766-71 ft, after treatment with 500 gal of acid.

CANADA

★ Canadian Bishop Oil Ltd., has reported that impassable roads are still holding up production tests on its Pembina No. 16-21 on a 160-acre Crown lease in the Pembina oilfield at Alberta Province. The well was perforated from 5098 to 5130 ft on August 12, but because of heavy rains it has been impossible to get testing supplies and equipment to the site. Seven-inch casing has been set to 5232 ft.

★ Canadian Prospect, Ltd., has completed its second oil producer in the Big Valley North area of Alberta. First well is in LSD 16, section 26, township 35, range 20, W.4. The second one to the west of it is in LSD 15 of the same section. On initial test the first Big Valley North well flowed 144 bbl in 2 hours. The second flowed 120 bbl on restricted choke.

CALIFORNIA

★ Universal Consolidated Oil Company has completed its second well on the 260 acre, 20th Century-Fox Studio lease. The well came in for a reported 750 bbl per day rate of 24 gravity oil. The discovery well flowed at a rate of 525 bbl per day when completed several months ago. Universal Consolidated will start a third well on the Fox lease soon employing the use of electrical drilling equipment.

★ Standard Oil Company of California has completed No. 27-F-82, a southwesterly extension of the Leda zone production in the Guijarral Hills area. Well is flowing at a rate of 1500 bbl per day of 34 deg gravity crude from a drilled depth of 8793 ft.

★ Jack B. Crawford, has completed his second well at Huntington Beach. Well is flowing from the Crawford sand, a new zone in the Miocene, at a rate of 525 bbl per day of 26 gravity crude. The well proves up the extension of a fault block the young geologist discovered a year ago.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Aug. 9	Aug. 16	Aug. 23	Aug. 30	Sept. 7	Sept. 13
Pacific Coast	120	121	122	125	125	127
Oklahoma	328	299	295	283	286	281
Kansas	168	169	183	169	159	154
Rocky Mountains	255	262	258	248	245	231
Canada	157	140	145	128	118	116
Ark-La-Tex	163	166	173	175	173	187
West Texas and New Mexico	456	444	441	419	437	442
Gulf Coast	536	504	496	487	478	478
Illinois	114	129	123	143	161	147
North Texas	313	301	298	277	288	276
	2610	2535	2534	2454	2470	2439

*As reported to Hughes Tool Company by the American Association of Oilwell Drilling Contractors.

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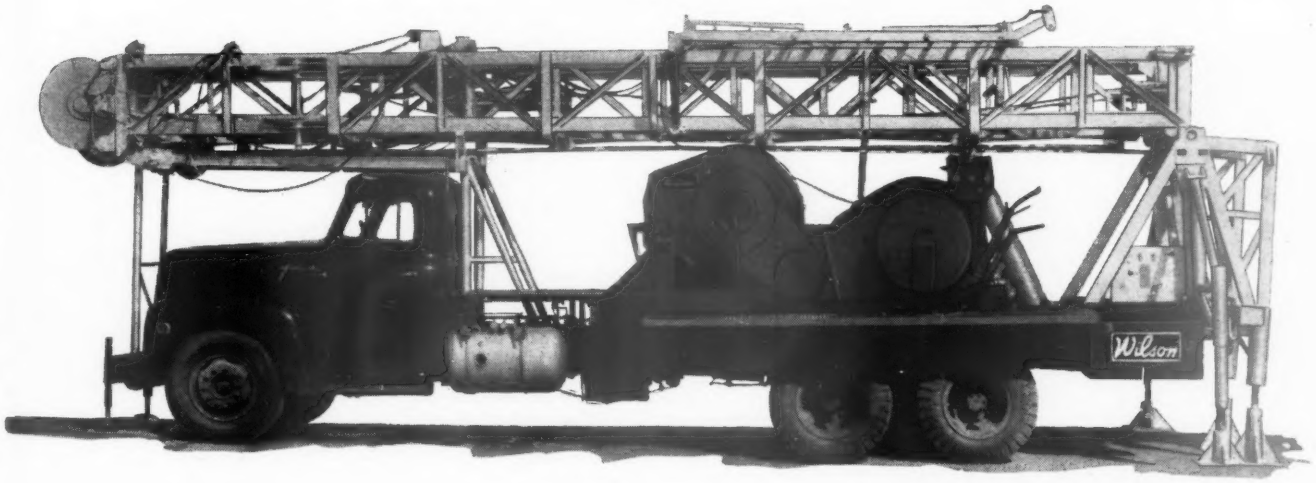

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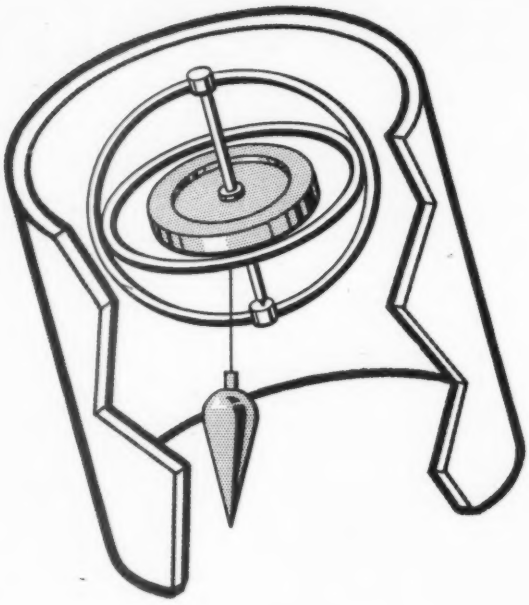

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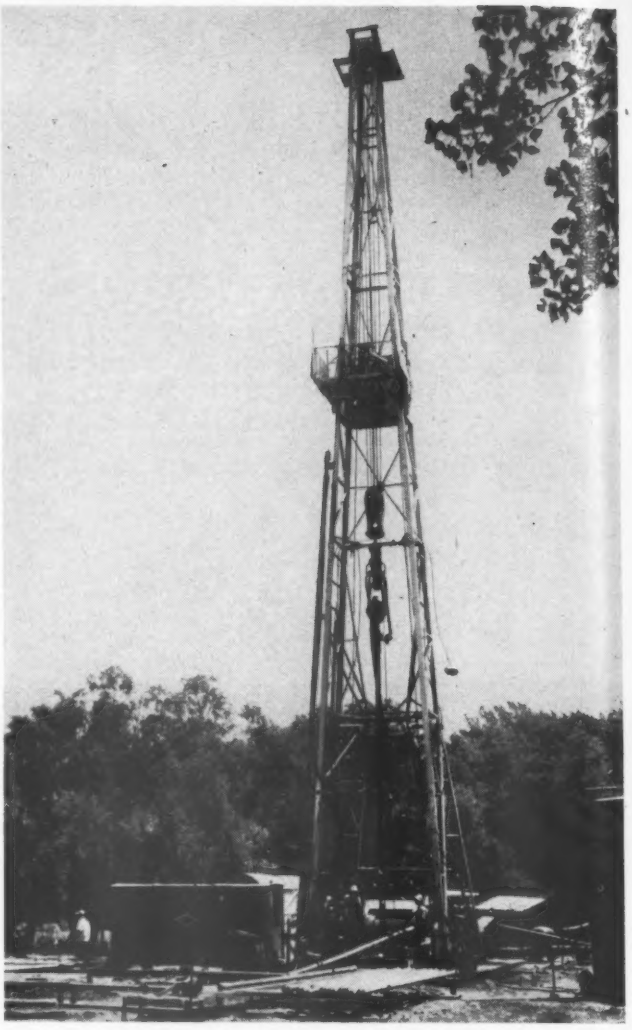

This T-32, GM Diesel powered National rig, owned and operated by Dan Kornfeld of Wichita, Kansas, has just completed its 90th hole for a total of approximately 360,000 ft drilled in less than 3 years. Holes averaged 4000 ft and took 10 to 12 days each to complete including moving and rigging time. Engines have each logged 24,000 hours without overhauls.

LOUISIANA

★ Cities Service has completed the No. 26-P Leblanc in Terrebonne Parish at a total depth of 12,014 ft. Producing through casing perforations from 11,482-495 ft, well yielded gas and condensate with a calculated open flow potential of 135,000,000 cu ft per day. Gas condensate ratio was 21 bbl per million.

★ Carter Oil has extended gas-distillate production a mile north of the Ivan field of Bossier Parish. The No. 1 C Crystal was completed in the Davis sand at 9201 ft with a potential of 3,500,000 cu ft per day and 300 bbl of 55.5 deg condensate through a ¼-in. choke. Well cut a net pay section of 16 ft in the interval 9170-9201 ft. Flowing tubing pressure was 2600 lb.

OKLAHOMA

★ W. A. Delaney, Jr's., No. 1 Randolph, stepout to the Hoover pool in Garvin county, flowed 120 bbl of oil on a 4-hour drillstem test in the second Tuley sand at 3242-90 ft. Well surfaced gas in 2 minutes, oil in 50 minutes.

★ Sterling Oil et al have a gas-distillate producer in the Barnes field of Garfield County, with their No. 1 Wolfe, flowing an estimated 73 bbl of 53-deg distillate an hour on a 20-minute drillstem test at 4812-27 ft. Test surfaced gas in 2 minutes, with oil flowing in 8 minutes.

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EXPLORATION ACTIVITIES

OKLAHOMA

Of particular interest to many of the smaller operators is the announcement of the discovery of production in the Tulip sand of Ordovician age in Carter County. The No. 1 Saive, Gilmer Oil et al owners, has completed in the Tulip at 1700 ft. Well encountered 82 ft of sand and was tested for 629 bbl of 42 deg oil in 19½ hours through ½-in. choke.

This well may well reverse previous ideas of the unlikelihood of Ordovician production in this part of the state. Location is 7 miles southwest of Ardmore.

CANADA

★ Union Oil Company has announced the completion of Liberal 15-31, a wildcat in the South Sturgeon Lake area of Northwestern Alberta. Well, a joint project between Union and Hudson's Bay Oil Company, came in at a rate of 4476 bbl per day of 38 deg crude.

★ Valley Oil Company Ltd. has abandoned its Great-Northern-Souris Valley Coulter Company No. 16-16, the deepest well in Manitoba. Well was drilled to 7000 ft at a cost of $100,000. Most producing wells in the province are about 3000 ft deep.

WYOMING

★ A completion flow in excess of 1000 bbl a day has been announced for the Forest Oil wildcat in Natrona County, the No. 22-1 Grieve Unit. Production from the well which is some 35 miles southwest of Casper, is from sands of Cretaceous age encountered 6723 to 6780 ft.

CALIFORNIA

★ Richfield Oil Corporation has been authorized by the State Lands Commission to explore for oil in the offshore area from the north boundry line of Ventura County to the Mexican border. The exploration will be active from September 15 to December 14 in waters off Ventura, Los Angeles, Orange, and San Diego counties.

★ Ohio Oil Company has completed F. E. Smith Government No. 1, a wildcat ½ mile NW of the Belgian Anticline field in Kern County. The well flowed 475 bbl at 32.5 deg oil in a 12 hour test, through a 22/64-in. bean. Ohio is now preparing to drill F. E. Smith No. 2.

TEXAS

★ Cities Service has reported a ¼ mile northeast extension of the West World pool, Crockett County, Texas, after drillstem testing its Shannon C. No. 2.

On test of the Pennsylvania Reef Limestone from 8080 to 8185 ft, gas was obtained in 4 minutes, mud in 17 minutes, and oil in 20 minutes. Well flowed 50 bbl of 47.2 deg oil in 1 hour and 10 minutes with a gas-oil ratio of 2100 to 1. Initial flowing pressure was 1350 lb, final flowing pressure was 2125 lb and shut-in pressure 3580 lb.

KANSAS

★ Falcon Seaboard Drilling Company has acquired a 7-well drilling block tract totalling 42,000 acres in central and eastern Kiowa County, Kansas.

First hole will be located in township 29-16w, southwest of Greensburg, and additional tests are slated for adjacent townships.

Kiowa County has been surrounded by drilling, but has been overlooked previously in the extensive wildcatting along the central Kansas uplift.

Recent good showings in wildcats in the extreme northern and northwestern parts of Kiowa have increased interest in the county. Another wildcat will soon be under way in southern Edwards County, north of Kiowa.

LOUISIANA

★ The deepest test ever to be drilled on Venice dome in Plaquemines Parish, Louisiana, has been spudded by Tide Water Associated Oil Company. The well, a semi-wildcat 3 locations north and west of the nearest producing wells, is projected to 17,000 ft, where the operators anticipate hitting salt. Prospect is in the Manhattan E-2 on the west flank of the dome proper.

Deepest well drilled previously was Tide Water A-24, which was drilled to 15,522 ft on the same flank and plugged back to 13,700 ft for production. There are multiple Miocene sands productive in the piercement type salt dome field.

MISSISSIPPI

★ The Jet Drilling Company et al No. 1 McKee in Wilkinson County, 1½ miles northeast of Lake Mary has a new Wilcox field discovery for the state. While being tested through perforations in the interval 7465-50 ft, the well flowed at the rate of 5 bbl an hour through a 7/64-in. choke with a GOR of 400 to 1. Operation is currently being offset to the north by Bateman Drilling Company.

Summary of Drilling Activity for August.

(As Complied by Rinehart Oil News Staff)

States	New locations Wc.	New locations Field	Wildcat completions Oil	Wildcat completions Gas	Wildcat completions Dry	Field completions Oil	Field completions Gas	Field completions Dry	Junked & abnd. Wc.	Junked & abnd. Fld.	Temp. abnd. Wc.	Temp. abnd. Field	Abnd. locations Wc.	Abnd. locations Field	Current active wells Wc.	Current active wells Field
Alabama	6	0	0	0	2	0	0	1	0	0	0	0	0	0	4	0
Arizona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Arkansas	13	39	0	0	12	20	0	15	1	0	0	0	2	1	12	20
Canada (Williston B.)	23	55	0	0	18	35	0	6	0	0	0	1	2	4	19	17
Colorado	59	33	2	3	41	31	1	19	0	0	0	3	2	2	50	30
Florida	3	0	0	0	6	0	0	0	0	0	0	0	0	0	1	1
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Kansas	104	337	8	3	78	223	23	105	0	0	0	0	0	1	70	274
Louisiana	48	312	4	4	39	185	48	42	0	2	2	5	2	15	55	229
North	17	164	3	1	14	116	9	8	0	0	1	1	1	10	14	49
South	31	148	1	3	25	69	39	34	0	2	1	4	1	5	41	180
Mississippi	19	31	0	0	12	14	3	6	0	0	1	0	0	0	15	27
Montana	16	14	0	0	14	10	1	3	0	0	1	0	6	1	26	23
Eastern	2	4	0	0	5	2	0	1	0	0	0	0	2	0	10	6
Western	14	10	0	0	9	8	1	2	0	0	1	0	4	1	16	17
North Dakota	15	18	0	0	13	26	0	1	0	0	0	0	0	0	13	20
Nebraska	19	27	3	0	21	16	1	9	0	0	0	0	1	0	18	23
Nevada	0	0	0	0	1	0	0	0	0	0	3	0	0	0	1	0
New Mexico	11	86	2	7	8	34	32	3	0	0	3	0	0	3	52	138
Eastern	10	64	2	0	6	34	11	3	0	0	1	0	0	2	42	108
San Juan	1	22	0	7	2	0	21	0	0	0	2	0	0	1	10	30
Oklahoma	56	562	11	0	61	387	20	154	1	0	0	1	4	15	68	598
South Dakota	3	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
Texas	446	1294	79	21	383	838	97	232	3	3	5	6	8	38	382	854
East	26	70	3	0	33	28	14	13	0	0	0	0	0	3	25	101
Gulf Coast	42	103	0	5	34	77	10	30	0	3	1	0	1	4	53	100
North Texas	95	318	22	1	61	199	2	85	0	0	0	0	0	2	42	97
Panhandle	2	84	1	1	6	36	37	2	0	0	0	0	0	1	16	21*
South Texas	109	176	5	7	97	144	25	43	3	0	3	5	1	12	61	116
Border Co.	25	74	6	0	25	37	0	5	0	0	0	0	1	0	27	66
West Central	104	186	25	5	73	127	1	46	0	0	0	0	2	2	37	47
West Texas	43	283	17	2	54	190	8	8	0	0	1	1	3	14	121	306
Utah	7	1	0	0	3	0	0	0	0	0	1	1	3	0	21	8
Wyoming	39	71	2	0	21	29	0	20	0	0	0	3	1	3	59	87
Totals: Jan.	699	2425	121	47	611	1780	254	584	6	5	10	21	17	144	808	2359
Feb.	713	2816	101	28	503	1583	228	542	0	5	21	22	29	98	845	2362
Mar.	975	2945	115	42	585	1866	242	605	0	6	27	33	16	69	950	2659
April	966	3166	117	46	665	2006	186	618	2	4	20	24	25	108	953	2665
May	879	2727	92	35	600	1762	170	478	2	2	29	21	13	92	945	2580
June	1074	2978	110	42	704	1759	250	524	4	2	36	59	35	113	1008	2640
July	1018	2940	132	42	727	2059	255	666	1	4	15	40	14	117	936	2361
Aug.	887	2880	111	38	734	1848	226	616	5	5	17	20	31	83	872	2349
1954 Total	7211	22,877	899	320	5129	14,663	1811	4633	20	33	175	240	180	824	—	—

* Figure incomplete.

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Exploration

NEW MEXICO

★ Lion Oil No. 1-C State, Lea County, 20 miles west of Tatum, is a Pennsylvania discovery. On drillstem test 9726-90 ft, well flowed oil to the surface in 53 minutes at a rate of 25 bbl per hour. Well had shown for an oiler previously on test from 9620-9725 ft.

ILLINOIS

★ Toklan Royalty Corporation has successfully confirmed a new Rosiclare pool in White County. The No. 1-A Ackerman was finaled flowing 50 bbl of oil in 10 hours from 3030-35 ft.

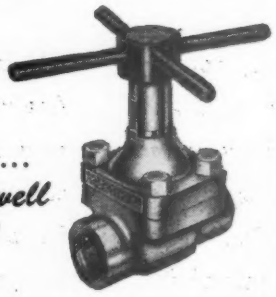
ARIZONA

★ Shell Oil Company has announced encouraging results from a drillstem test on its East Boundary Butte well No. 2 in Apache County.

During a 2½ hour test between 4535 and 4601 ft the well produced a strong blow of gas rated at 3,500,000 cu ft per day.

The well, located approximately 15 miles west of the junction point of the Arizona, Colorado, New Mexico, and Utah boundaries, is Shell's second try in the area within the past few months. The first, East Boundary Butte No. 1, 5 miles west of No. 2, encountered gas but not in commercial quantities. Gas production from this well is currently being utilized as fuel for drilling No. 2.

An ALL-NEW mudline valve



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The lower the expense of producing source water from wells for water flooding operations, the greater the ultimate profit.

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Improved design and longer operating life *lower* the cost of labor per barrel, *lower* the cost of maintenance per barrel, *lower* the investment cost per barrel, *lower* the cost of fluid per barrel.

Also the ability of Reda pumps to produce greater volumes in limited casing sizes and from greater depths often reduces the number of source water wells required.

Reda engineers have long been associated with water flooding operations and are fully qualified to assist operators in discussing their source water requirements.

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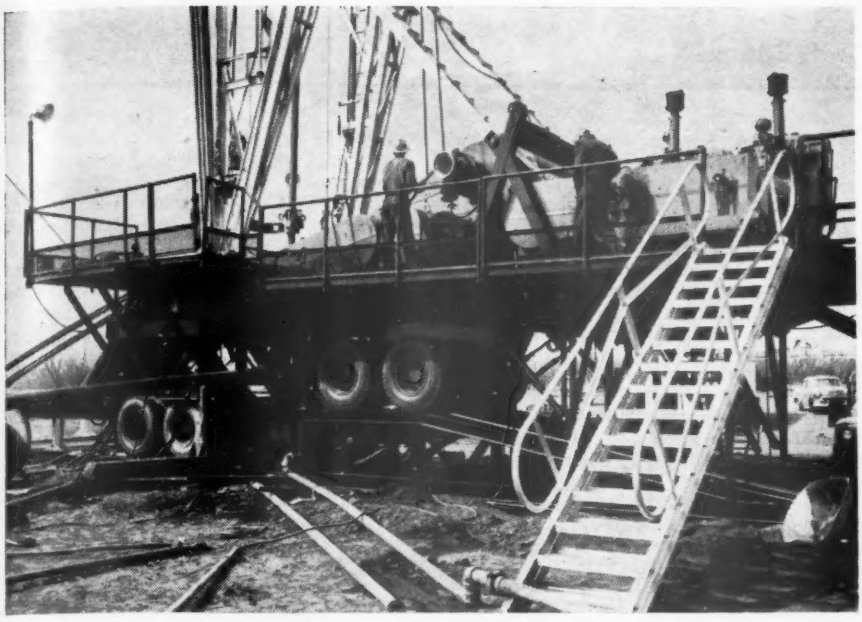

FIG. 1. View of dual-trailer rig of Magnolia Petroleum Company. Rig is a T-20-S, manufactured by The National Supply Company, with a 97-ft, heavy-duty, Lee C. Moore mast.

West Texas Rig Features

PORTABILITY

A dual-trailer rig has been placed in service by the Magnolia Petroleum Company in west Texas.

Distribution of the load between two trailers permits use of more powerful equipment than on a single trailer, while keeping the weight within the limit to 18,000 lb per axle that is enforced in a number of states.

Rig has a 200 input horsepower draw works*, with a 97-ft, heavy duty, mast. It is powered by a dual torque converter engine drive. Other equipment includes a 17½-in. rotary and a combination hook block. The draw works is equipped with a 15-in. double rotor hydromatic brake.

The draw works, engines, and mast support frame are on one trailer with the total weight distributed to place 17,710 lb on each rear axle. The other trailer carries the mast, rotary substructure, rotary, and hook-block, with 16,750 lb on each rear axle.

The mast trailer is 35 ft 11 in. from the kingpin to the center line of the dual axle. With the mast retracted to the traveling position, and folded over the cab of the tractor truck, it has an overall length of 65 ft 6¼ in. and a height of 13½ ft.

On arrival at the drilling site, the trailers are rigidly coupled, end to end, on ramps that support them at suitable heights above the ground, to provide clearance for blow-out preventer equipment. The weight of the load is distributed on jacks.

Power from the draw works is used to raise the gin poles and extend the top section of the mast in a horizontal position. The mast is then raised with the traveling block and a sling line. The back legs of the mast are attached to the support frame on the draw works trailer. No guys are required.

Hinged floors, which are folded out of the way while traveling, can be set up quickly at the drilling location, providing walkways for crew. All air lines are manifolded into substructure. Three metal stairways give access to derrick floor. * * *

*National Ideal T-20-S.

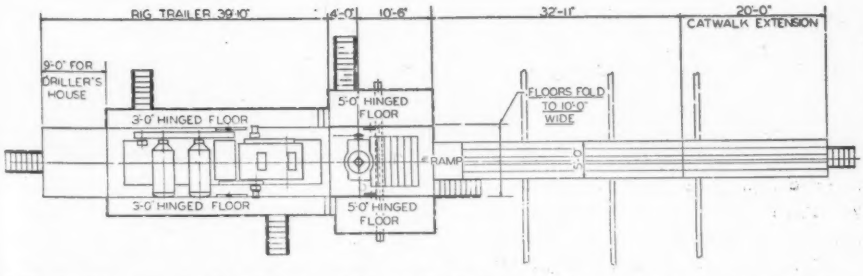

FIG. 2. Diagram dual-trailer rig of Magnolia Petroleum Company set up for operation.

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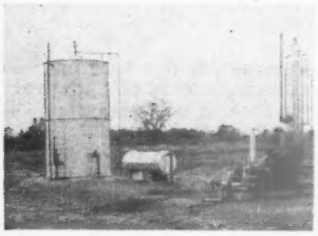

Clay County, Texas

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ESTIMATES
DESIGN
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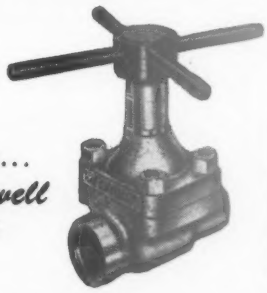

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RUNNING TOUR with MEN in the INDUSTRY

Robert H. Love has been transferred from Great Bend, Kansas, to Lion Oil Company's Oklahoma City production and exploration office. Love assumes the position of district landman in the Oklahoma district, having served over a year as landman at Great Bend. He is a graduate of the University of Arkansas law school.

Kenneth R. Boles has been made general manager of Cimarron Drilling and Cimarron Western Drilling, subsidiaries of Beach and Talbot interests. He was formerly with Samedan Oil at Ardmore, Oklahoma.

J. Peter Smith has resigned from the geological department of Carter Oil Company to become an independent oil producer and geological-engineer. Smith is a graduate of the University of Texas.

Joseph H. Goth, Jr., has been named head of a new Warren-Bradshaw Exploration Company division office in Denver, Colorado. Goth, formerly with Continental Oil Company, attended Lehigh University and the University of Pittsburgh.

Joseph T. Dawson and **Joseph L. Cramer** have formed a partnership and will operate as the firm of Dawson and Cramer, with offices at 516 Symes Building, Denver, Colorado. Firm will concentrate on drilling operations in the Denver Basin.

J. E. Clark has been named manager of Shell Oil Company's Midland, Texas exploration and production department. A graduate of Stanford University, Clark served in the Rocky Mountain area before moving to Midland. He succeeds **Joe T. Dickerson** who will be president of Shell Pipe Line Corporation.

Macon A. Banner, senior district clerk for Humble Oil and Refining Company's production department in Stratton district, southwest Texas division has been promoted to assistant district chief clerk at the Colorado district. **George Dickens** was transferred to the Anahuac district, Gulf Coast division, as toolpusher. **G. D. Bradenberry** was transferred to the Avoca district in North Texas as assistant district chief clerk.

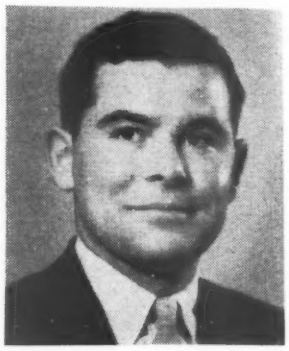
R. C. Barbour, Jr., was transferred to Athens district, East Texas division, as petroleum engineer. **Billy W. Evans** was transferred to Katy gas cycling plant as gas engineer. **Donald D. Cherry** was transferred to the East Texas division, as civil engineer. **A. E. Petty** was promoted to farm boss in the Palestine district. **C. W. Bonds** was transferred to Athens district, East Texas division, as driller.

John R. Leonard has been promoted to division geologist of the Panhandle area by the Phillips Petroleum Company. He was formerly staff geologist of the northwest division in Bartlesville, Oklahoma.

Charles T. Crewell has been named area land agent for Shell Oil Company's Calgary, Canada, area. He will be replaced as San Joaquin division land manager by **Durland E. Clark, Jr.**

Benson M. (Benny) Kingston, who recently resigned as assistant manager and technical advisor of The Chemical Process Company, has opened petroleum engineering and geological consulting offices in the Burch Hotel Building, Breckenridge, Texas. Kingston is co-inventor and patent holder of the permeability survey and acidizing control systems marketed as Permeter Services, and a type of mud-acid, trade named Mudsol, used for cleansing wells of drilling mud. He attended the Universities of Texas and Oklahoma.

O. D. Harper has been named manager of Carter Oil Company's production department at Tulsa, Oklahoma. He replaces **C. G. Herrington,** who will devote his full time as a director of the company.



P. C. Badgley

Dr. Peter C. Badgley has resigned as district geologist for Husky Oil and Refining Ltd., for Alberta, and joined West Maygill Gas and Oil Ltd. as exploration manager. Badgley graduated from McGill University with a B.S. degree and the Logan Gold Medal in geological sciences. He later did graduate work in geology at Princeton University, receiving M.A. and Ph.D. degrees. Badgley's previous experience in the gas and oil industry of Western Canada has been with the Western Oil and Gas Division of the Geological Survey of Canada and the California Standard Company.

Donald E. Everet, petroleum engineer with Union Oil Company of California has been transferred from the Orcutt, California, office to Los Angeles where he will work on offshore problems.

Standard Oil Company of California engineers have completed a course in advanced reservoir engineering at The College of Mineral Industries of The Pennsylvania State University. Course was of 4 weeks duration and 100 hours of instruction. Engineers who participated in the course were: Front row: Henry Yaplee, R. J. Miescke, T. J. Leighner, R. W. Donaldson, H. H. Rushing, H. B. Dodson, and A. L. Wood. Second row: J. E. Warren, W. R. Voss, D. D. Little, C. F. Dwyer, H. F. Copeland, R. B. Dees, and S. F. Craddock. Third row: Dave Oakes, L. C. Zeer, R. B. Bossler, PGCOA, R. A. Roberts, W. J. Hunter, E. L. Dildine, and J. C. Calhoun, instructor.

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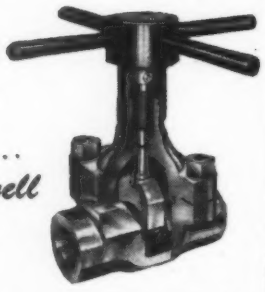

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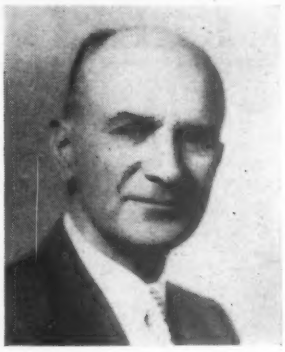


D. E. Davis

▸ **D. E. Davis** has been appointed manager of Standard-Vacuum Oil Company's producing department in New York, New York. He succeeds **E. W. Berlin** whose temporary assignment with Stanvac's operating subsidiary in Indonesia has been extended.

Davis, a graduate in mining engineering at the University of Washington, joined an affiliate of Standard of New Jersey in the Argentine. He began his oil career in 1923 with the Carter Oil Company.

▸ **Robert H. Mansfield** has joined the Southern California Petroleum Corporation as exploration geophysicist. Mansfield was formerly associated with United Geophysical Company.

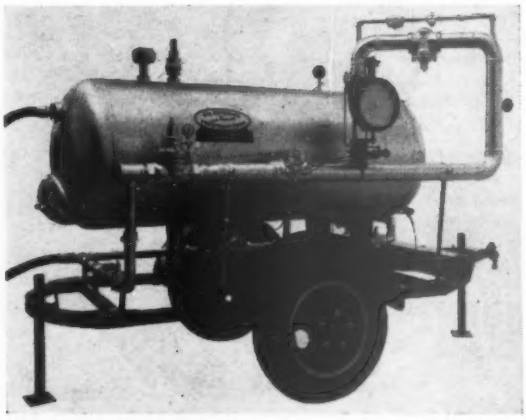
▸ **Marshall R. Joy** has joined the Frankfort Oil Company as manager of production. Joy was formerly manager of production for the Brazos Oil and Gas Company in Mount Pleasant, Michigan.

▸ **Willard A. Sanger,** district geologist for Pure Oil Company in Michigan, has been named to the state advisory board. Board advises Gerold E. Eddy, state supervisor of wells.

▸ **Jim R. Ramsey** has opened an office as a petroleum consultant at 670 Skirvin Tower, Oklahoma City, Oklahoma. Ramsey was formerly with Stanolind Oil and Gas Company.

▸ **Charles F. Gates** has been advanced to the post of chief production engineer for General Petroleum Corporation's production department. Gates joined General Petroleum in 1938, shortly after his graduation from the California Institute of Technology. In 1949 he became senior production engineer at Vernon, California, the post he held until his promotion.

WELL TESTERS



PERMANENT OR PORTABLE — Oil Metering Test Separators are furnished in permanent or portable (trailer-mounted) types, in sizes and working pressures to meet all requirements.

TEST SEPARATORS — Well fluid is separated into oil, gas and water; any one or all may be metered. The degassing and defoaming element assures maximum oil metering accuracy by removing non-solution gas from the oil, and by breaking up foam.

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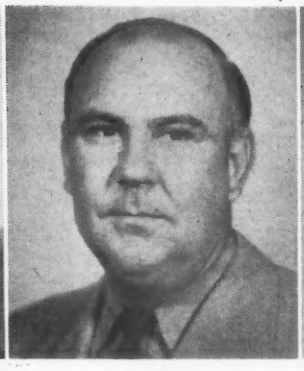
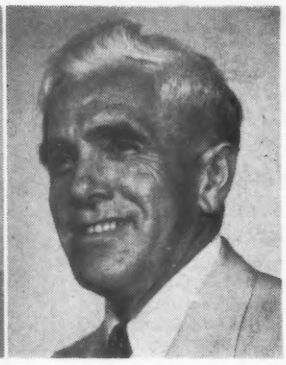


J. J. Marty



J. K. Rogers

R. E. Heithecker has opened a consulting office at 6103 Martel Avenue, Dallas, Texas. He will work as a consulting engineer in the fields of petroleum and natural gas. He was formerly with Seaboard Oil Company's natural gas and reservoir engineering departments in Dallas. A graduate of Purdue University, Heithecker was with the Bureau of Mines from 1926 until 1945, at which time he joined Staboard.

Roy P. Hardy, geologist with M. B. Armer, independent producer of Wichita, Texas, has resigned to become a consultant. Hardy was formerly with Gulf and Amerada.

Jack C. West has been named district geologist by Hancock Oil Company at its Bakersfield, California, offices. **Bob Pascal** has been named to a similar position at Hancock's new offices opened in Ventura, California.

Joe J. Marty has been named division exploration manager for Arkansas Fuel Oil Corporation in San Antonio, Texas. He will have on his staff **John C. Bianchi,** district geologist; **A. V. Hargis,** district geophysicist; and **Francis E. Ruffin,** assistant district landman. **Dr. James K. Rogers** has been named regional research geologist.

Marty joined Arkansas Fuel Oil Corporation at their San Antonio office in 1937. Rogers is a graduate of Syracuse University. After working with the Ohio and United States Geological Surveys, Rogers joined Arkansas Fuel Oil Corporation in 1937 and did surface work and mapping in North Arkansas until being transferred to the Houston office in 1939.

Bianchi has been with the company since August 1, 1949, when he entered service as a geologist in the Shreveport office. He is a graduate of the University of Texas. **A. V. Hargis** joined the company in July, 1951. He studied geology and petroleum engineering at the University of Texas. Ruffin, a graduate of the University of Georgia, joined the company's San Antonio office as a scout in 1952.

M. C. Hoffman has been appointed division production superintendent of Stanolind Oil and Gas Company's Calgary, Canada producing department. **Sidney B. Richards** has been named division engineer, and **C. E. Dagley** was named division clerk. **C. O. Hopper,** district superintendent, has been transferred to Edmonton.

Hoffman, a graduate of Colorado A and M College, joined Stanolind in 1931 as a gas engineer in Tulsa, Oklahoma. He had been vice president for production and exploration for Pan-Am Southern.

Richards joined the company in 1939 following graduation from the University of Oklahoma with a degree in petroleum engineering. He was petroleum engineering supervisor in Stanolind's general office in Tulsa before his appointment.

Dagley, who joined the company in 1941, was transferred from Houston, Texas in 1952. He was formerly district clerk in Calgary.

Robert L. Whiting has been named head of the Department of Petroleum Engineering of the A and M College of Texas. A graduate in petroleum engineering from the University of Texas, Whiting was formerly employed as a petroleum reservoir engineer by Stanolind Oil and Gas Company.

Dan M. Bass has been appointed assistant professor of Petroleum Engineering at A and M. Bass is a graduate of Louisiana State University. He was formerly employed as a petroleum engineer by the Magnolia Petroleum Company in its West Texas division.

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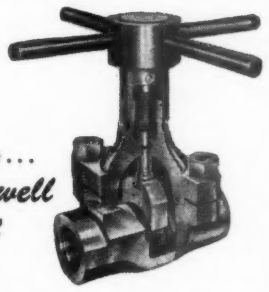

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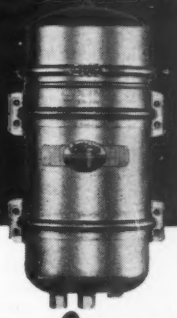

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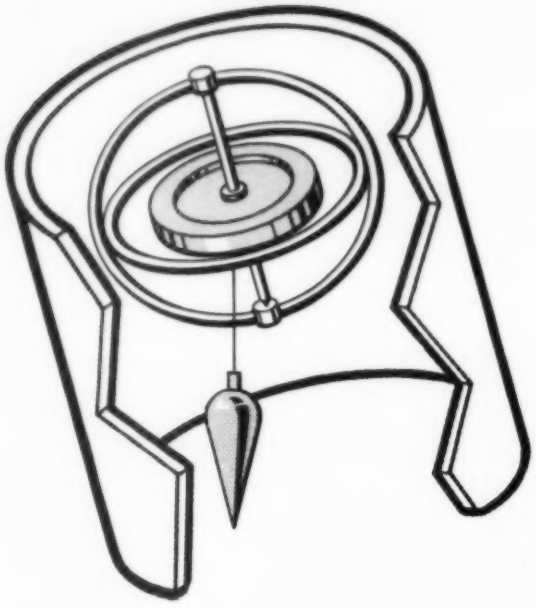

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Polar Core Orientation
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Over these past 25 years Sperry-Sun Well Surveying Instruments and Technical Services have been among the producers' greatest aids in assuring fast, accurate and profitable drilling.

Any branch office can give you detailed information.

SPERRY-SUN WELL SURVEYING COMPANY

3118 Blodgett Avenue Houston, Texas

This T-32, GM Diesel powered National rig, owned and operated by Dan Kornfeld of Wichita, Kansas, has just completed its 90th hole for a total of approximately 360,000 ft drilled in less than 3 years. Holes averaged 4000 ft and took 10 to 12 days each to complete including moving and rigging time. Engines have each logged 24,000 hours without overhauls.

LOUISIANA

★ Cities Service has completed the No. 26-P Leblanc in Terrebonne Parish at a total depth of 12,014 ft. Producing through casing perforations from 11,482-495 ft, well yielded gas and condensate with a calculated open flow potential of 135,000,000 cu ft per day. Gas condensate ratio was 21 bbl per million.

★ Carter Oil has extended gas-distillate production a mile north of the Ivan field of Bossier Parish. The No. 1 C Crystal was completed in the Davis sand at 9201 ft with a potential of 3,500,000 cu ft per day and 300 bbl of 55.5 deg condensate through a ¼-in. choke. Well cut a net pay section of 16 ft in the interval 9170-9201 ft. Flowing tubing pressure was 2600 lb.

OKLAHOMA

★ W. A. Delaney, Jr's., No. 1 Randolph, stepout to the Hoover pool in Garvin county, flowed 120 bbl of oil on a 4-hour drillstem test in the second Tuley sand at 3242-90 ft. Well surfaced gas in 2 minutes, oil in 50 minutes.

★ Sterling Oil et al have a gas-distillate producer in the Barnes field of Garfield County, with their No. 1 Wolfe, flowing an estimated 73 bbl of 53-deg distillate an hour on a 20-minute drillstem test at 4812-27 ft. Test surfaced gas in 2 minutes, with oil flowing in 8 minutes.

XUM

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a New Line of Traveling Blocks

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MODEL	NO. SHEAVES	SHEAVE DIA.	CAPACITY
BH-430-A	4	30"	100 TONS
BH-438-A	4	38"	150 TONS

BLOCKS			
MODEL	NO. SHEAVES	SHEAVE DIA.	CAPACITY
B-430-A	4	30"	125 TONS
B-438-A	4	38"	200 TONS
B-544-A	5	44"	300 TONS

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EXPLORATION ACTIVITIES

OKLAHOMA

Of particular interest to many of the smaller operators is the announcement of the discovery of production in the Tulip sand of Ordovician age in Carter County. The No. 1 Saive, Gilmer Oil et al owners, has completed in the Tulip at 1700 ft. Well encountered 82 ft of sand and was tested for 629 bbl of 42 deg oil in 19½ hours through ½-in. choke.

This well may well reverse previous ideas of the unlikelihood of Ordovician production in this part of the state. Location is 7 miles southwest of Ardmore.

CANADA

★ Union Oil Company has announced the completion of Liberal 15-31, a wildcat in the South Sturgeon Lake area of Northwestern Alberta. Well, a joint project between Union and Hudson's Bay Oil Company, came in at a rate of 4476 bbl per day of 38 deg crude.

★ Valley Oil Company Ltd. has abandoned its Great-Northern-Souris Valley Coulter Company No. 16-16, the deepest well in Manitoba. Well was drilled to 7000 ft at a cost of $100,000. Most producing wells in the province are about 3000 ft deep.

WYOMING

★ A completion flow in excess of 1000 bbl a day has been announced for the Forest Oil wildcat in Natrona County, the No. 22-1 Grieve Unit. Production from the well which is some 35 miles southwest of Casper, is from sands of Cretaceous age encountered 6723 to 6780 ft.

CALIFORNIA

★ Richfield Oil Corporation has been authorized by the State Lands Commission to explore for oil in the offshore area from the north boundry line of Ventura County to the Mexican border. The exploration will be active from September 15 to December 14 in waters off Ventura, Los Angeles, Orange, and San Diego counties.

★ Ohio Oil Company has completed F. E. Smith Government No. 1, a wildcat ½ mile NW of the Belgian Anticline field in Kern County. The well flowed 475 bbl at 32.5 deg oil in a 12 hour test, through a 22/64-in. bean. Ohio is now preparing to drill F. E. Smith No. 2.

TEXAS

★ Cities Service has reported a ¼ mile northeast extension of the West World pool, Crockett County, Texas, after drillstem testing its Shannon C. No. 2.

On test of the Pennsylvania Reef Limestone from 8080 to 8185 ft, gas was obtained in 4 minutes, mud in 17 minutes, and oil in 20 minutes. Well flowed 50 bbl of 47.2 deg oil in 1 hour and 10 minutes with a gas-oil ratio of 2100 to 1. Initial flowing pressure was 1350 lb, final flowing pressure was 2125 lb and shut-in pressure 3580 lb.

KANSAS

★ Falcon Seaboard Drilling Company has acquired a 7-well drilling block tract totalling 42,000 acres in central and eastern Kiowa County, Kansas.

First hole will be located in township 29-16w, southwest of Greensburg, and additional tests are slated for adjacent townships.

Kiowa County has been surrounded by drilling, but has been overlooked previously in the extensive wildcatting along the central Kansas uplift.

Recent good showings in wildcats in the extreme northern and northwestern parts of Kiowa have increased interest in the county. Another wildcat will soon be under way in southern Edwards County, north of Kiowa.

LOUISIANA

★ The deepest test ever to be drilled on Venice dome in Plaquemines Parish, Louisiana, has been spudded by Tide Water Associated Oil Company. The well, a semi-wildcat 3 locations north and west of the nearest producing wells, is projected to 17,000 ft, where the operators anticipate hitting salt. Prospect is in the Manhattan E-2 on the west flank of the dome proper.

Deepest well drilled previously was Tide Water A-24, which was drilled to 15,522 ft on the same flank and plugged back to 13,700 ft for production. There are multiple Miocene sands productive in the piercement type salt dome field.

MISSISSIPPI

★ The Jet Drilling Company et al No. 1 McKee in Wilkinson County, 1½ miles northeast of Lake Mary has a new Wilcox field discovery for the state. While being tested through perforations in the interval 7465-50 ft, the well flowed at the rate of 5 bbl an hour through a 7/64-in. choke with a GOR of 400 to 1. Operation is currently being offset to the north by Bateman Drilling Company.

Summary of Drilling Activity for August.

(As Complied by Rinehart Oil News Staff)

States	New locations Wc.	New locations Field	Wildcat completions Oil	Wildcat completions Gas	Wildcat completions Dry	Field completions Oil	Field completions Gas	Field completions Dry	Junked & abnd. Wc.	Junked & abnd. Fld.	Temp. abnd. Wc.	Temp. abnd. Field	Abnd. locations Wc.	Abnd. locations Field	Current active wells Wc.	Current active wells Field
Alabama	6	0	0	0	2	0	0	1	0	0	0	0	0	0	4	0
Arizona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Arkansas	13	39	0	0	12	20	0	15	1	0	0	0	2	1	12	20
Canada (Williston B.)	23	55	0	0	18	35	0	6	0	0	0	1	2	4	19	17
Colorado	59	33	2	3	41	31	1	19	0	0	0	3	2	2	50	30
Florida	3	0	0	0	6	0	0	0	0	0	0	0	0	0	1	1
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Kansas	104	337	8	3	78	223	23	105	0	0	0	0	0	1	70	274
Louisiana	48	312	4	4	39	185	48	42	0	2	2	5	2	15	55	229
North	17	164	3	1	14	116	9	8	0	0	1	1	1	10	14	49
South	31	148	1	3	25	69	39	34	0	2	1	4	1	5	41	180
Mississippi	19	31	0	0	12	14	3	6	0	0	1	0	0	0	15	27
Montana	16	14	0	0	14	10	1	3	0	0	1	0	6	1	26	23
Eastern	2	4	0	0	5	2	0	1	0	0	0	0	2	0	10	6
Western	14	10	0	0	9	8	1	2	0	0	1	0	4	1	16	17
North Dakota	15	18	0	0	13	26	0	1	0	0	0	0	0	0	13	20
Nebraska	19	27	3	0	21	16	1	9	0	0	0	0	1	0	18	23
Nevada	0	0	0	0	1	0	0	0	0	0	3	0	0	0	1	0
New Mexico	11	86	2	7	8	34	32	3	0	0	3	0	0	3	52	138
Eastern	10	64	2	0	6	34	11	3	0	0	1	0	0	2	42	108
San Juan	1	22	0	7	2	0	21	0	0	0	2	0	0	1	10	30
Oklahoma	56	562	11	0	61	387	20	154	1	0	0	1	4	15	68	598
South Dakota	3	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
Texas	446	1294	79	21	383	838	97	232	3	3	5	6	8	38	382	854
East	26	70	3	0	33	28	14	13	0	0	0	0	0	3	25	101
Gulf Coast	42	103	0	5	34	77	10	30	0	3	1	0	1	4	53	100
North Texas	95	318	22	1	61	199	2	85	0	0	0	0	0	2	42	97
Panhandle	2	84	1	1	6	36	37	2	0	0	0	0	0	1	16	21*
South Texas	109	176	5	7	97	144	25	43	3	0	3	5	1	12	61	116
Border Co.	25	74	6	0	25	37	0	5	0	0	0	0	1	0	27	66
West Central	104	186	25	5	73	127	1	46	0	0	0	0	2	2	37	47
West Texas	43	283	17	2	54	190	8	8	0	0	1	1	3	14	121	306
Utah	7	1	0	0	3	0	0	0	0	0	1	1	3	0	21	8
Wyoming	39	71	2	0	21	29	0	20	0	0	0	3	1	3	59	87
Totals: Jan.	699	2425	121	47	611	1780	254	584	6	5	10	21	17	144	808	2359
Feb.	713	2816	101	28	503	1583	228	542	0	5	21	22	29	98	845	2362
Mar.	975	2945	115	42	585	1866	242	605	0	6	27	33	16	69	950	2659
April	966	3166	117	46	665	2006	186	618	2	4	20	24	25	108	953	2665
May	879	2727	92	35	600	1762	170	478	2	2	29	21	13	92	945	2580
June	1074	2978	110	42	704	1759	250	524	4	2	36	59	35	113	1008	2640
July	1018	2940	132	42	727	2059	255	666	1	4	15	40	14	117	936	2361
Aug.	887	2880	111	38	734	1848	226	616	5	5	17	20	31	83	872	2349
1954 Total	7211	22,877	899	320	5129	14,663	1811	4633	20	33	175	240	180	824	—	—

* Figure incomplete.

Courtesy Rinehart Oil Reports

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Exploration

NEW MEXICO

★ Lion Oil No. 1-C State, Lea County, 20 miles west of Tatum, is a Pennsylvania discovery. On drillstem test 9726-90 ft, well flowed oil to the surface in 53 minutes at a rate of 25 bbl per hour. Well had shown for an oiler previously on test from 9620-9725 ft.

ILLINOIS

★ Toklan Royalty Corporation has successfully confirmed a new Rosiclare pool in White County. The No. 1-A Ackerman was finaled flowing 50 bbl of oil in 10 hours from 3030-35 ft.

ARIZONA

★ Shell Oil Company has announced encouraging results from a drillstem test on its East Boundary Butte well No. 2 in Apache County.

During a 2½ hour test between 4535 and 4601 ft the well produced a strong blow of gas rated at 3,500,000 cu ft per day.

The well, located approximately 15 miles west of the junction point of the Arizona, Colorado, New Mexico, and Utah boundaries, is Shell's second try in the area within the past few months. The first, East Boundary Butte No. 1, 5 miles west of No. 2, encountered gas but not in commercial quantities. Gas production from this well is currently being utilized as fuel for drilling No. 2.

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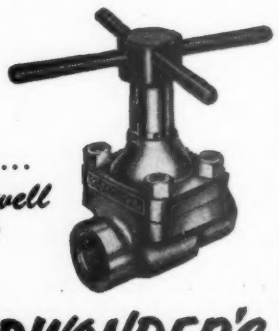

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Reda engineers have long been associated with water flooding operations and are fully qualified to assist operators in discussing their source water requirements.

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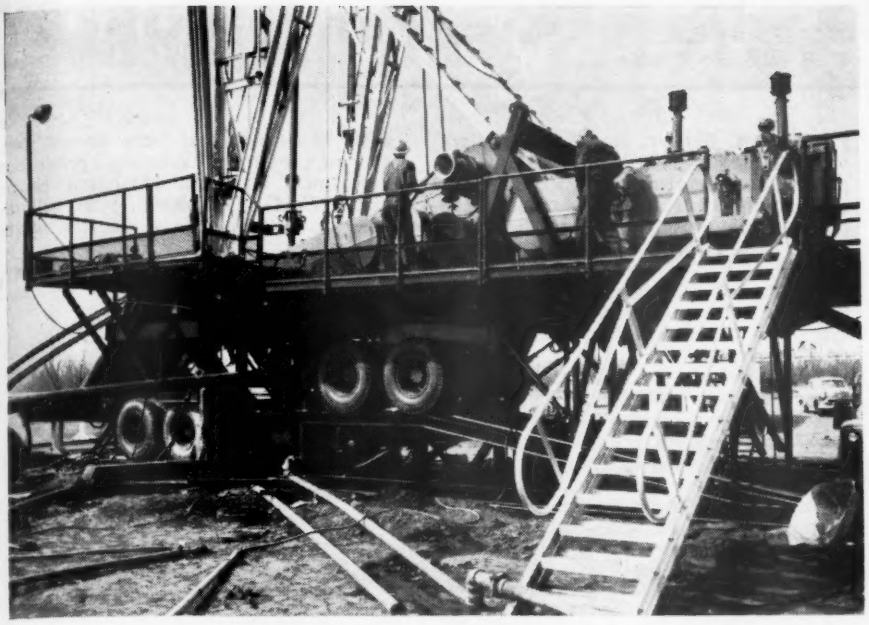

FIG. 1. View of dual-trailer rig of Magnolia Petroleum Company. Rig is a T-20-S, manufactured by The National Supply Company, with a 97-ft, heavy-duty, Lee C. Moore mast.

West Texas Rig Features

PORTABILITY

A dual-trailer rig has been placed in service by the Magnolia Petroleum Company in west Texas.

Distribution of the load between two trailers permits use of more powerful equipment than on a single trailer, while keeping the weight within the limit to 18,000 lb per axle that is enforced in a number of states.

Rig has a 200 input horsepower draw works*, with a 97-ft, heavy duty, mast. It is powered by a dual torque converter engine drive. Other equipment includes a 17½-in. rotary and a combination hook block. The draw works is equipped with a 15-in. double rotor hydromatic brake.

The draw works, engines, and mast support frame are on one trailer with the total weight distributed to place 17,710 lb on each rear axle. The other trailer carries the mast, rotary substructure, rotary, and hook-block, with 16,750 lb on each rear axle.

The mast trailer is 35 ft 11 in. from the kingpin to the center line of the dual axle. With the mast retracted to the traveling position, and folded over the cab of the tractor truck, it has an overall length of 65 ft 6¼ in. and a height of 13½ ft.

On arrival at the drilling site, the trailers are rigidly coupled, end to end, on ramps that support them at suitable heights above the ground, to provide clearance for blow-out preventer equipment. The weight of the load is distributed on jacks.

Power from the draw works is used to raise the gin poles and extend the top section of the mast in a horizontal position. The mast is then raised with the traveling block and a sling line. The back legs of the mast are attached to the support frame on the draw works trailer. No guys are required.

Hinged floors, which are folded out of the way while traveling, can be set up quickly at the drilling location, providing walkways for crew. All air lines are manifolded into substructure. Three metal stairways give access to derrick floor. * * *

*National Ideal T-20-S.

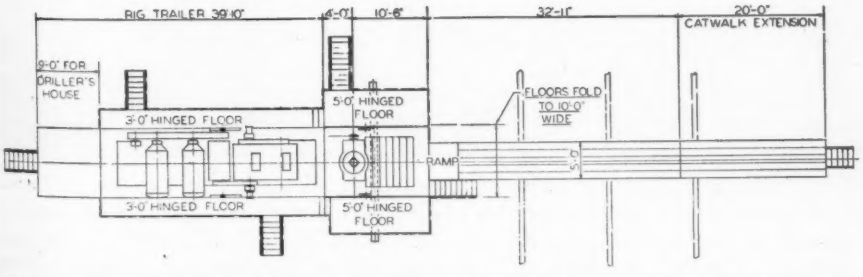

FIG. 2. Diagram dual-trailer rig of Magnolia Petroleum Company set up for operation.

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RUNNING TOUR with MEN in the INDUSTRY

Robert H. Love has been transferred from Great Bend, Kansas, to Lion Oil Company's Oklahoma City production and exploration office. Love assumes the position of district landman in the Oklahoma district, having served over a year as landman at Great Bend. He is a graduate of the University of Arkansas law school.

Kenneth R. Boles has been made general manager of Cimarron Drilling and Cimarron Western Drilling, subsidiaries of Beach and Talbot interests. He was formerly with Samedan Oil at Ardmore, Oklahoma.

J. Peter Smith has resigned from the geological department of Carter Oil Company to become an independent oil producer and geological-engineer. Smith is a graduate of the University of Texas.

Joseph H. Goth, Jr., has been named head of a new Warren-Bradshaw Exploration Company division office in Denver, Colorado. Goth, formerly with Continental Oil Company, attended Lehigh University and the University of Pittsburgh.

Joseph T. Dawson and **Joseph L. Cramer** have formed a partnership and will operate as the firm of Dawson and Cramer, with offices at 516 Symes Building, Denver, Colorado. Firm will concentrate on drilling operations in the Denver Basin.

J. E. Clark has been named manager of Shell Oil Company's Midland, Texas exploration and production department. A graduate of Stanford University, Clark served in the Rocky Mountain area before moving to Midland. He succeeds **Joe T. Dickerson** who will be president of Shell Pipe Line Corporation.

Macon A. Banner, senior district clerk for Humble Oil and Refining Company's production department in Stratton district, southwest Texas division has been promoted to assistant district chief clerk at the Colorado district. **George Dickens** was transferred to the Anahuac district, Gulf Coast division, as toolpusher. **G. D. Bradenberry** was transferred to the Avoca district in North Texas as assistant district chief clerk.

R. C. Barbour, Jr., was transferred to Athens district, East Texas division, as petroleum engineer. **Billy W. Evans** was transferred to Katy gas cycling plant as gas engineer. **Donald D. Cherry** was transferred to the East Texas division, as civil engineer. **A. E. Petty** was promoted to farm boss in the Palestine district. **C. W. Bonds** was transferred to Athens district, East Texas division, as driller.

John R. Leonard has been promoted to division geologist of the Panhandle area by the Phillips Petroleum Company. He was formerly staff geologist of the northwest division in Bartlesville, Oklahoma.

Charles T. Crewell has been named area land agent for Shell Oil Company's Calgary, Canada, area. He will be replaced as San Joaquin division land manager by **Durland E. Clark, Jr.**

Benson M. (Benny) Kingston, who recently resigned as assistant manager and technical advisor of The Chemical Process Company, has opened petroleum engineering and geological consulting offices in the Burch Hotel Building, Breckenridge, Texas. Kingston is co-inventor and patent holder of the permeability survey and acidizing control systems marketed as Permeter Services, and a type of mud-acid, trade named Mudsol, used for cleansing wells of drilling mud. He attended the Universities of Texas and Oklahoma.

O. D. Harper has been named manager of Carter Oil Company's production department at Tulsa, Oklahoma. He replaces **C. G. Herrington,** who will devote his full time as a director of the company.

P. C. Badgley

Dr. Peter C. Badgley has resigned as district geologist for Husky Oil and Refining Ltd., for Alberta, and joined West Maygill Gas and Oil Ltd. as exploration manager. Badgley graduated from McGill University with a B.S. degree and the Logan Gold Medal in geological sciences. He later did graduate work in geology at Princeton University, receiving M.A. and Ph.D. degrees. Badgley's previous experience in the gas and oil industry of Western Canada has been with the Western Oil and Gas Division of the Geological Survey of Canada and the California Standard Company.

Donald E. Everet, petroleum engineer with Union Oil Company of California has been transferred from the Orcutt, California, office to Los Angeles where he will work on offshore problems.

Standard Oil Company of California engineers have completed a course in advanced reservoir engineering at The College of Mineral Industries of The Pennsylvania State University. Course was of 4 weeks duration and 100 hours of instruction. Engineers who participated in the course were: Front row: Henry Yaplee, R. J. Miescke, T. J. Leighner, R. W. Donaldson, H. H. Rushing, H. B. Dodson, and A. L. Wood. Second row: J. E. Warren, W. R. Voss, D. D. Little, C. F. Dwyer, H. F. Copeland, R. B. Dees, and S. F. Craddock. Third row: Dave Oakes, L. C. Zeer, R. B. Bossler, PGCOA, R. A. Roberts, W. J. Hunter, E. L. Dildine, and J. C. Calhoun, instructor.

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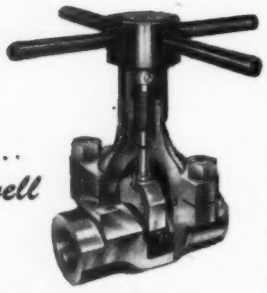

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D. E. Davis

D. E. Davis has been appointed manager of Standard-Vacuum Oil Company's producing department in New York, New York. He succeeds **E. W. Berlin** whose temporary assignment with Stanvac's operating subsidiary in Indonesia has been extended.

Davis, a graduate in mining engineering at the University of Washington, joined an affiliate of Standard of New Jersey in the Argentine. He began his oil career in 1923 with the Carter Oil Company.

Robert H. Mansfield has joined the Southern California Petroleum Corporation as exploration geophysicist. Mansfield was formerly associated with United Geophysical Company.

Marshall R. Joy has joined the Frankfort Oil Company as manager of production. Joy was formerly manager of production for the Brazos Oil and Gas Company in Mount Pleasant, Michigan.

Willard A. Sanger, district geologist for Pure Oil Company in Michigan, has been named to the state advisory board. Board advises Gerold E. Eddy, state supervisor of wells.

Jim R. Ramsey has opened an office as a petroleum consultant at 670 Skirvin Tower, Oklahoma City, Oklahoma. Ramsey was formerly with Stanolind Oil and Gas Company.

Charles F. Gates has been advanced to the post of chief production engineer for General Petroleum Corporation's production department. Gates joined General Petroleum in 1938, shortly after his graduation from the California Institute of Technology. In 1949 he became senior production engineer at Vernon, California, the post he held until his promotion.

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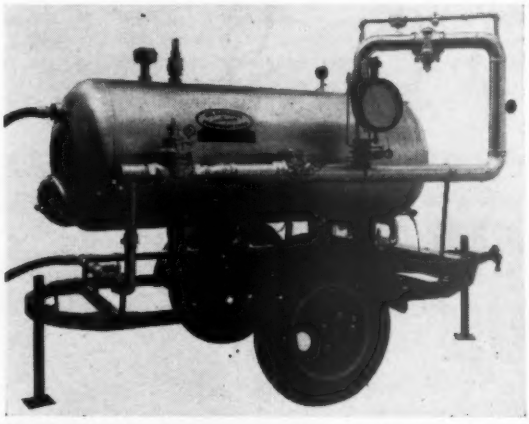

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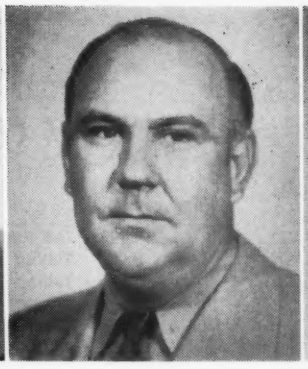
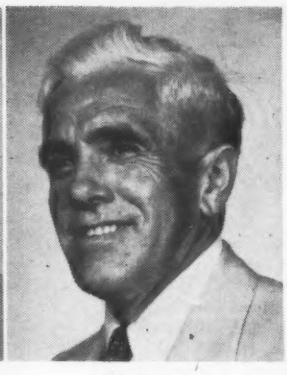
R. E. Heithecker



J. J. Marty



J. K. Rogers

R. E. Heithecker has opened a consulting office at 6103 Martel Avenue, Dallas, Texas. He will work as a consulting engineer in the fields of petroleum and natural gas. He was formerly with Seaboard Oil Company's natural gas and reservoir engineering departments in Dallas. A graduate of Purdue University, Heithecker was with the Bureau of Mines from 1926 until 1945, at which time he joined Staboard.

Roy P. Hardy, geologist with M. B. Armer, independent producer of Wichita, Texas, has resigned to become a consultant. Hardy was formerly with Gulf and Amerada.

Jack C. West has been named district geologist by Hancock Oil Company at its Bakersfield, California, offices. **Bob Pascal** has been named to a similar position at Hancock's new offices opened in Ventura, California.

Joe J. Marty has been named division exploration manager for Arkansas Fuel Oil Corporation in San Antonio, Texas. He will have on his staff **John C. Bianchi,** district geologist; **A. V. Hargis,** district geophysicist; and **Francis E. Ruffin,** assistant district landman. **Dr. James K. Rogers** has been named regional research geologist.

Marty joined Arkansas Fuel Oil Corporation at their San Antonio office in 1937. Rogers is a graduate of Syracuse University. After working with the Ohio and United States Geological Surveys, Rogers joined Arkansas Fuel Oil Corporation in 1937 and did surface work and mapping in North Arkansas until being transferred to the Houston office in 1939.

Bianchi has been with the company since August 1, 1949, when he entered service as a geologist in the Shreveport office. He is a graduate of the University of Texas. **A. V. Hargis** joined the company in July, 1951. He studied geology and petroleum engineering at the University of Texas. Ruffin, a graduate of the University of Georgia, joined the company's San Antonio office as a scout in 1952.

M. C. Hoffman has been appointed division production superintendent of Stanolind Oil and Gas Company's Calgary, Canada producing department. **Sidney B. Richards** has been named division engineer, and **C. E. Dagley** was named division clerk. **C. O. Hopper,** district superintendent, has been transferred to Edmonton.

Hoffman, a graduate of Colorado A and M College, joined Stanolind in 1931 as a gas engineer in Tulsa, Oklahoma. He had been vice president for production and exploration for Pan-Am Southern.

Richards joined the company in 1939 following graduation from the University of Oklahoma with a degree in petroleum engineering. He was petroleum engineering supervisor in Stanolind's general office in Tulsa before his appointment.

Dagley, who joined the company in 1941, was transferred from Houston, Texas in 1952. He was formerly district clerk in Calgary.

Robert L. Whiting has been named head of the Department of Petroleum Engineering of the A and M College of Texas. A graduate in petroleum engineering from the University of Texas, Whiting was formerly employed as a petroleum reservoir engineer by Stanolind Oil and Gas Company.

Dan M. Bass has been appointed assistant professor of Petroleum Engineering at A and M. Bass is a graduate of Louisiana State University. He was formerly employed as a petroleum engineer by the Magnolia Petroleum Company in its West Texas division.

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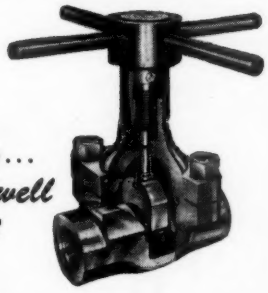

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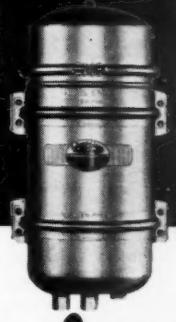

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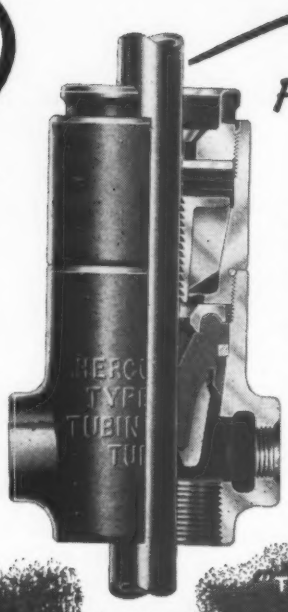

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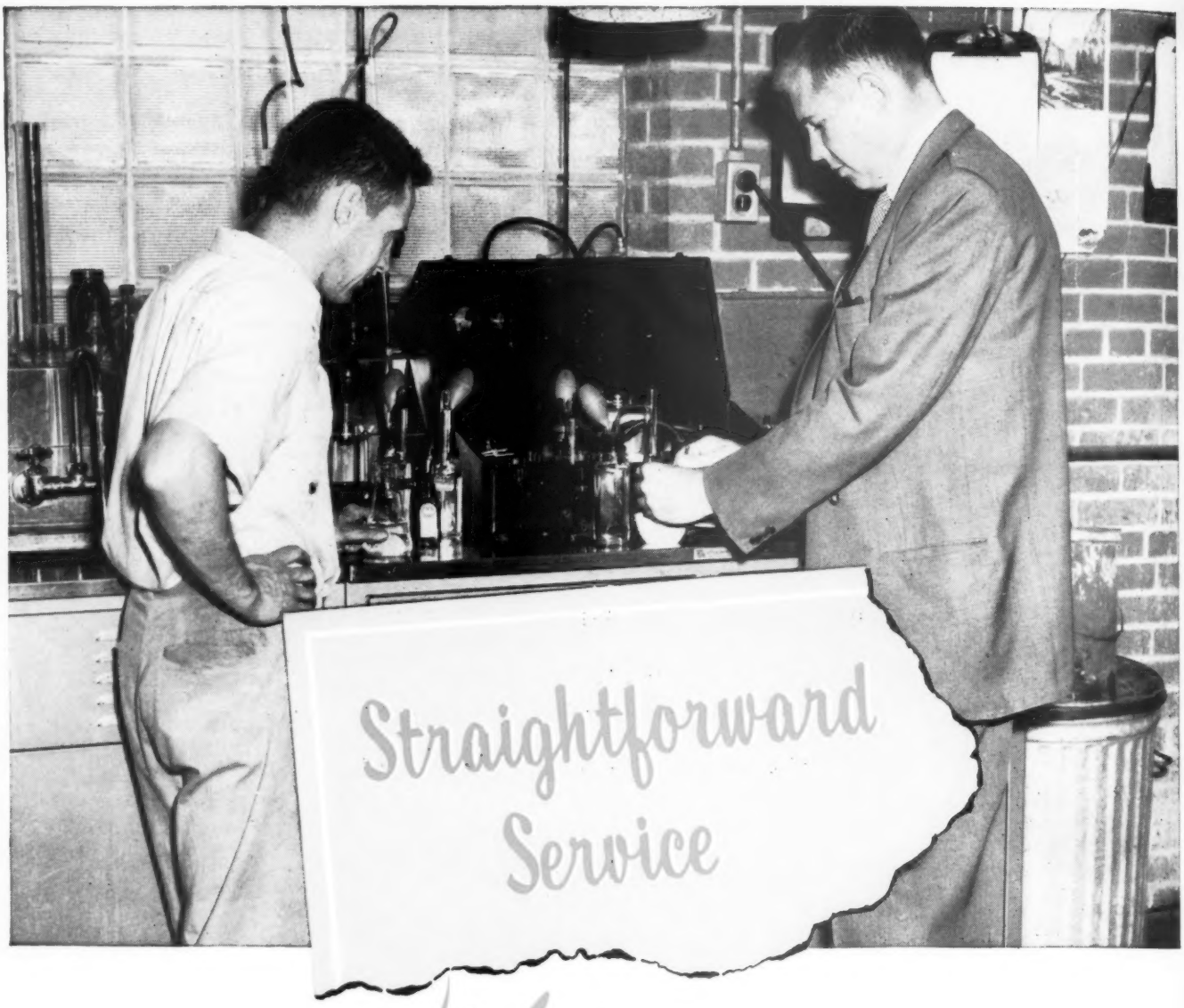

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A paper on "A Laboratory Method for the Study of Steam Condensate Corrosion Inhibitors," presented at the 8th Annual Conference, National Association of Corrosion Engineers, has been reprinted by Nalco for distribution to men interested in this problem. Your copy will be sent free upon request.

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DIGEST of NEWS and COMMENT ★ ★ ★

Refining . . . Petrochemical . . . Gas Processing

Too Little to Too Much

Anglo-Iranian may be in the position of holding too great a surplus of refining capacity due to two recent developments—the beginning of operations at its new Aden, Arabia, refinery and the settlement of the dispute over the oil industry in Iran. Presumably reaching an agreement with Iran will hand back to AIOC management the "remains" of the huge Abadan refinery. To replace this "lost" capacity, Anglo-Iranian built refineries in England, Arabia, and elsewhere, assuming the conclusion that Abadan was lost to them via the pro-communist regime under Premier Mossadegh, deposed with the return of the pro-Western king. In mid-August a second 2,500,000 tons per year crude distillation unit was placed in operation at Aden, with other units coming on stream very soon in this $125,000,000 plant. The mechanical condition of Abadan units is not announced, of course; whether or not AIOC will reopen Abadan has not been announced.

★ ★ ★

Back to School

The now well established training system started by Humble Oil and Refining Company seven years ago begins its eighth season soon, to bring a selected group of Humble technologists up to date on recent scientific discoveries and our expanding knowledge. Each technical man on the staff is permitted to have at least one course each two years. Victor L. Streeter, University of Michigan, will give fluid mechanics; R. R. White, same school, lectures on scale-up of processes; oxidation of hydorcarbons will occupy the course by A. D. Walsh, of England's University of Leeds. C. R. Wylie, Jr., University of Utah, will explain chemical engineering mathematics and the series will be concluded by Charles Kittel, physics professor at University of California. Students are relieved of all other duties during these two-weeks courses.

★ ★ ★

Research Moves On

Expanded research on the applications of molybdenum chemicals to industrial uses is getting under way for Climax Molybdenum Company, a sure sign that this metal is now in excess of demand. Moly products or metal, the latter used widely in alloys, are employed especially in catalysts for the reforming of low-grade naphthas or gasolines. A very outstanding product is molybdenum sulfide, as a black powder employed in extremely difficult lubrication jobs, such as wire-drawing, and elsewhere as in the making of instruments where extreme precision is required. A new, 8000-sq ft building alongside the existing Climax Detroit, Michigan, laboratories has been acquired to house the new units.

★ ★ ★

Blankets for Motor Fuels?

Spreading an extremely thin "blanket" over the surface of gasoline or other hydrocarbon products in storage, not to keep it warm but to prevent its rapid disappearance by evaporation, is a new use for the so-called fluorocarbon products. These surfactants—surface-active agents to you—spread in a thin film over the liquid gasoline, as little as 0.002 per cent by weight of the gasoline being effective in changing the surface properties of the latter. Tests show that 0.003 per cent of F-2, one of the products of fluorine and carbon, held 75 per cent of a given quantity of gasoline covered by it, while all of a similar quantity of unprotected gasoline had evaporated under identical conditions. G. B. Balke, Minnesota Mining and Manufacturing Company (3M) researcher says addition of small amounts of these products to lubricants increases their wetting and/or pentrating properties. Indications are that these fluorocarbons will improve the penetrating properties of waxes used as coatings, and for other purposes.

★ ★ ★

Skull Practice at Mandan

A gang of "freshmen players" quarterbacked by old refining heads has been "scrimmaging" with its "plays" for operating the new 30,000 bbl Standard of Indiana refinery at Mandan, South Dakota, getting under way for the "opening game" October second, so say the Indiana "coaches."

The new hands were trained in five stages to make gasoline safely, they being mostly new recruits to the refining industry. The refinery will operate on Williston Basin crude. Squads of operators-to-be were trained at other Indiana refineries, such as Casper, Wyoming, Sugar Creek, Missouri, and in several other plants.

Test Tube to Tower

One of the biggest expenses in developing processes is the pilot plant step; calling for more researchers, heavier and more costly equipment, generally long periods of experimental operation, the pilot plant is at least a very costly transition step in modern industrial development.

Standard Oil Development Company, the great research-and-development branch of Standard Oil of New Jersey, is bridging that gap by working out ways and means of translating test-tube-scale or laboratory results into large-scale commercial plant design and operating details. The routine is being tackled by the use of so-called bench-scale units that have already shown positive results in two or three cases. At the Linden laboratory of S.O.D. the staff using a bench-scale unit, consisting of only one operator and charge streams measured in liters (large quarts) instead of barrels, and costs in dollars instead of hundreds of dollars daily, has worked out a fractionation system for a Hydroformer unit to produce streams to specifications. Also, in the effort to recover benzene, etc. quickly and efficiently from refinery streams, design data for a unit using phenol as selective solvent have been developed satisfactorily from similar bench-scale operations at low cost.

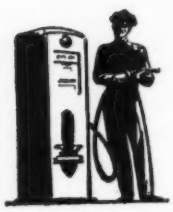
★ ★ ★

Combustion 'Bad Boy'?

The role of water vapor in air-hydrocarbon or other combustion mixtures is not yet understood fully, says du Pont researcher B. M. Sturgis. Running a test engine on pure hydrogen and on carbon monoxide containing no hydrogen but from which elimination of water vapor was not complete, shows that hydrogen knocks at about the same conditions as does 100-octane number iso-octane. Removing water vapor completely from the monoxide reduces markedly the tendency to knock, these men found. It is possible, they say that a perfectly dry carbon monoxide will not knock at all, and if so this seems to lend support to the idea that knocking may be related to the hydrogen- and oxygen-containing radicals. Addition of TEL seems to slow some of the later reactions of hydrocarbon combustion although apparently not affecting the earlier reactions appreciably.

B&W "CO" BOILER

Starts Saving For



RICHFIELD

OIL CORPORATION

at Watson, California

Another big stride in waste heat reclamation was made at Richfield's Watson refinery when their new B&W CO (Carbon Monoxide) Boiler recently went on stream.

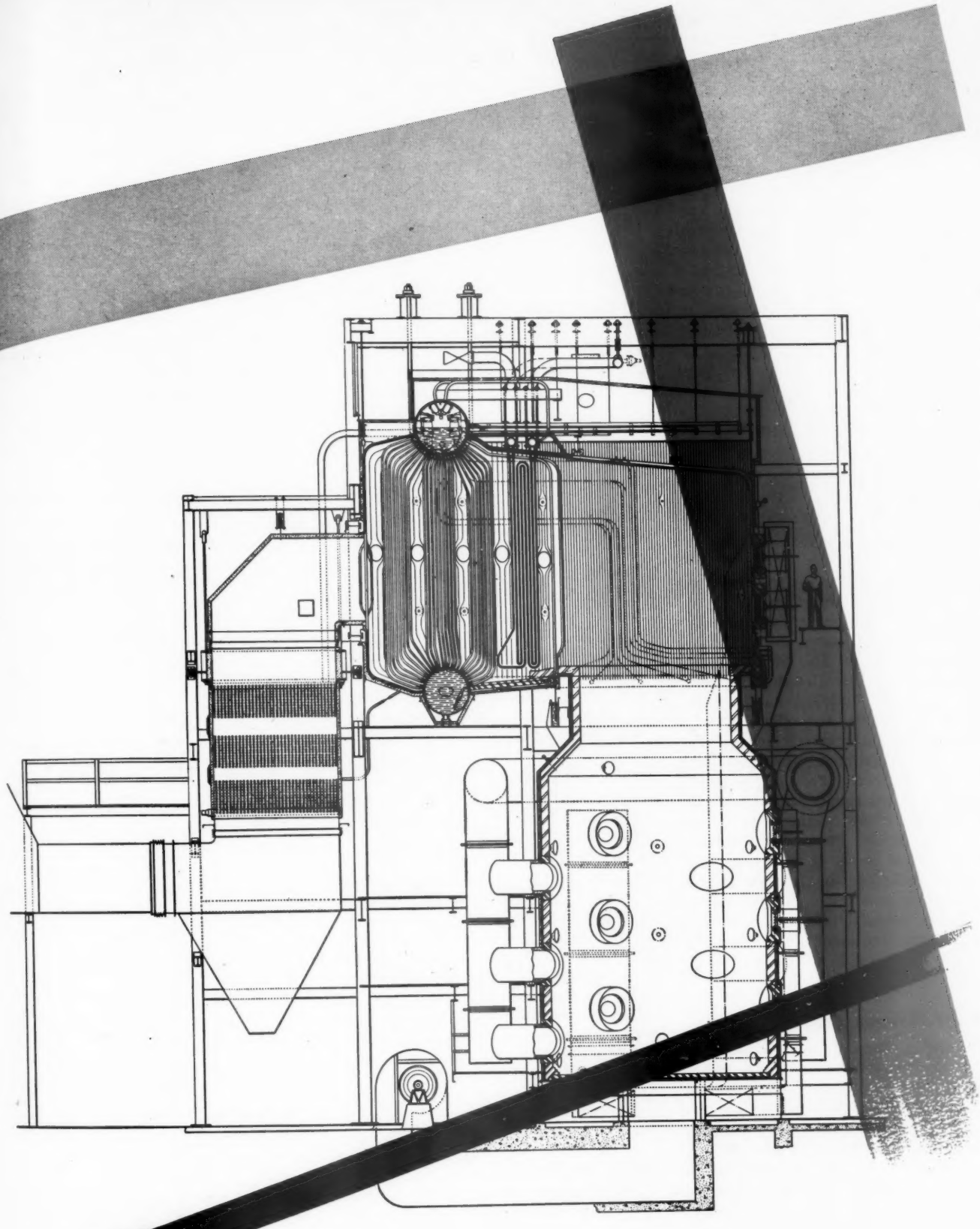
Utilizing the combustible carbon monoxide, as well as sensible heat, from the catalyst regenerator, the CO Boiler puts to work what previously was expelled to the atmosphere as waste. From now on this once costly disposal will be harnessed and burned — an efficiency that is best reckoned in dollars.

In addition, the boiler is an independent source of steam power for the entire fluid unit and its auxiliaries — operating even when the cracking unit is shut down.

Its maximum continuous capacity is 340,000 lb. of steam per hr at a pressure of 700 psi and a temperature of 750 F., burning either oil or fuel gas as primary fuels.

Besides representing a significant economic advance, the CO Boiler is an outstanding example of complete cooperation among companies with the common goal of lowering operating costs and raising an already extraordinary efficiency still higher. C. F. Braun Company, the contractors, Richfield Oil Corp, and B&W — all are major contributors to what is rapidly proving to be a *saving* advance in the petroleum industry. Let us discuss with you and with your consulting engineers the working advantages of the B&W CO Boiler and give you additional details. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

G-668



BABCOCK & WILCOX

BOILER DIVISION

Heavier Alcohols Coming?

Petrochemical pioneering Carbide and Carbon Chemicals Corporation is barging into the ranks of Oxo process operators at Texas City, to make 60,000,000 lb of acids, alcohols, aldehydes, and related products. The process operates at 1500-1600 psig to react carbon monoxide and hydrogen with olefins up to the 15-carbon atom class to give these products. Development of routines for making iso-octyl—to compete with Gulf Oil's product—primary decyl, and tridecyl alcohols have been completed in pilot plants at C&CC's Charlestown, West Virginia, plant. Probable outlets for these high molecular materials include polymerization end products, detergents, acid derivatives, plasticizers, and so on.

★ ★ ★

Doughnut for Research

A new petrochemical development laboratory built from an 80,000 bbl steel storage tank is the latest project of Continental Oil Company's research and development department at Ponca City, Oklahoma, the company's main refinery unit. The lab will have a hole cut out of the "doughnut," center of the circular building, with 3 floors around this hole, for offices, special laboratories, and other facilities for the staff of 60 additional scientists, chemists, and engineers. Presumably in the hole will be pilot plant equipment with a traveling crane overhead to handle heavy materials. Purpose of the new laboratory is to test in pilot plant operation the findings of the research laboratory on small scale in the petrochemical manufacturing field, Harold G. Osborn, Continental vice president said.

★ ★ ★

Multi-Grade Oils Best

A strong case is shown for the new, high viscosity index "multi-grade" crank-case lubricating oils in recent research on their performance in service as compared to other older type oils for the same purposes. Recent findings show that heavily compounded oils of multi-grade type and containing anti-corrosion and other additives are far and away best for all phases of engine operation; easier starting at low temperatures, safer viscosities at high operating temperatures, lower engine friction, better oil and better fuel economy, reduced octane requirement increases in the engine with increasing age, less valve train wear, and better detergency and oxidation stability. "Multi-grade oils are the logical crankcase lubricant for today's high performance passenger cars," said Moore, Kent, and Lakin of Union Oil Company before the Society of Automotive Engineers.

Comparative tests show that the wear factor on piston rings and cylinders with the use of conventional, oxidation inhibited oils to be represented by the numerical value, 450. With heavily compounded conventional oils this was reduced to 100. With heavily compounded multi-grade oils this wear rate was reduced to a comparative 80. For the uninitiated, multi-grade oils are those possessing such high viscosity in indices, that is, such a slow rate of viscosity change with temperature change, that they meet the specifications for two, three or more SAE grades. One such oil may be called a 10-30 W oil, and meet the requirements for 10, 20, and 30 W SAE grades.

★ ★ ★

Sludge Knocked Out

Knocking sludge-forming components of especially cracked gasolines by treatment with as little as 0.1 per cent of boron trifluoride, BF_3 to the chemists, is one of the most recent developments in gasoline refining. Gulf Oil's new process researchers Beuther and Goldthwait are the leading spirits in bringing this new process to commercial practice. The trifluoride is brought into contact with the raw gasoline at about room temperature and pressure for periods of 1 to 10 minutes, and the small amount of insoluble sludge formed is allowed to settle, then the gasoline is washed and redistilled to eliminate any soluble sludge-formers. It is said not to affect appreciably octane number or TEL susceptibility. Engines stay cleaner with fuel so treated, laboratory tests indicate, say the researchers, who disclosed the process before the American Chemical Society.

★ ★ ★

ACS to Meet

A Symposium on Hydrocarbon Chemistry will be held by Southeastern Texas Section, American Chemical Society, in Houston, Texas, January 27 and 28, 1955. Program will consist of papers by invited speakers representing outstanding authorities from all over the United States and Canada. Ample time is scheduled for presentation and discussion.

A dinner meeting is scheduled for January 27 at the Rice Hotel, headquarters of the symposium.

Hydrogen Via Pipe Line

Another solution of the excess hydrogen production on the one hand, and the need for excess hydrogen on the other appears in Shell Chemical's new plans for hydrogen for making ammonia, etc. Catalytic reformer operations at Shell Oil's Martinez refinery produces the excess of hydrogen over and above that of plant needs. Shell's nearby Pittsburg ammonia synthesis plant needs hydrogen, normally obtained by decomposition of natural gas, so Shell builds a 12-mile pipe line from Martinez to Pittsburg unit. The hydrogen will be used to make ammonia, while conserving natural gas for consumption by other local needs, domestic, and industrial.

★ ★ ★

Hamburg Bitumen Plant

A plant to produce the various grades of bituminous materials needed by the German market are in production now at the AIOC (Anglo-Iranian) refinery at Hamburg, Germany. Bottoms from the vacuum distillation unit commissioned earlier this year are concentrated to make the asphalts, etc. Unit can make 135,000 bbl per annum.

★ ★ ★

Olin-Mathieson Merges

Formal completion of the merger between the Olin Industries and Mathieson Chemical Corporation was announced as becoming effective August 31. New firm name is Olin Mathieson Chemical Corporation, with John M. Olin as board chairman, and T. S. Nichols as president; Nichols was Mathieson's president before the merger. New board of directors of the coalition met September 9. Both companies are of major size in their fields. Mathieson has large interest in manufacturing petrochemical and other organic chemicals, as well as some inorganics. Olin has various interests but heretofore none in the chemical field, but controls Western Cartridge Company and the old and famous Winchester Repeating Arms Company.

★ ★ ★

Dow Speeds Research

More facilities for latex research and development work is announced by Dow Chemical, at Midland, Michigan. Dow is pioneer in producing latex paints, paper coatings, etc., from styrene-butadiene latexes, the same intermediates used for G GR-S tire-type rubber. J. W. Britton will direct this new work, with D. A. Taber over the laboratory, and Max L. Bottomley managing product development units.

XUM

Ancient "refinery" in Newhall, California, said to be the oldest stills west of the Rockies.

P 701.

Refining—

From Pot Still to Cat Still

In 25 Years

Comparison of THEN and NOW in refining technology and plant operations shows the amazing speed of developments

ARCH L. FOSTER*

"FROM Thumb Rule to Slide Rule" may well typify the progress of the refining industry during the last quarter-century. While the "art" of refining was beginning to take on some of the watermarks of science, engineering, chemistry, technology by 1929, the state of technological development was practically in embryo, and only the most farseeing of the industry's leaders could read with any prophetic clarity the pattern of things to come.

Obviously the greatest attention has been paid by the industry to developments in processing, to the ways and means for making products that possess the properties required by the consumers, rather than to refine the products that seemed easiest to make from the crude at hand. Yet hand-in-hand with process advances inevitably went improvements in equipment, in metals, and in materials that would permit operation of processes under conditions that would make the required products. Cracking, for example, not only waited on process developments; new ideas were forced to wait often for years on discoveries in steels, pumps, tubes, and fractionators.

To determine which of the two "legs" of refining — processes and equipment — is the more important to the final outcome of refining is like attempting to say which of the two legs of the human being is the more important for standing or walking.

The tremendous strides in refining since the 1920's are the result of intensive, collaborative effort between engineering organizations, refiners, and the research groups as represented by the engineering colleges and institutes. Without any one of these three the tripod of progress could not have stood on its "feet." Another principle of great import to the industry is the interchange of data, of the results of research and of large-scale operations, a trend and a practice that has made the oil industry unique in the annals of industrial evolution.

The Cracking Saga

At the beginning of the quarter-century just closing the art of "cracking," or molecular decomposition of heavier hydrocarbons was just emerging from its "swaddling clothes," a

*Editor, Refining and Petrochemical Edition.

EXCLUSIVE

Anglo-Iranian Oil Company's famous 450,000 bbl per day refinery at Abadan. Typical of the most modern of today's refineries before it was taken over by the Iranian government, its present physical condition is unknown.

lusty, unruly, little-understood giant "infant," taking its toll of men's lives, toil, thought; offering prospects for successful gambles, of plunges into hitherto unexplored regions of technology. To use the desert trail analogy, the path followed by the cracking industry is littered by many, many "wrecks" of processes, methods, and men; many more than have survived in any form to become very or partially successful.

In the late 1920's cracking by thermal means was emerging into its second era of development. Earlier, Dr. W. M. Burton, pioneer of pioneers, later Dr. R. E. Humphreys, both of Standard of Indiana, had developed the Burton still, designed on the basis of the old shell still. Nearly 900 of them had operated for several years, many under license from Indiana for other refineries, and had become obsolete in the mid-twenties. It is claimed that the increase in gasoline percentage yield made possible by the Burton still saved this country, in the 15 years the still was active in refining, a billion barrels of crude oil. Production of this extra amount of crude could have been well nigh impossible at that time.

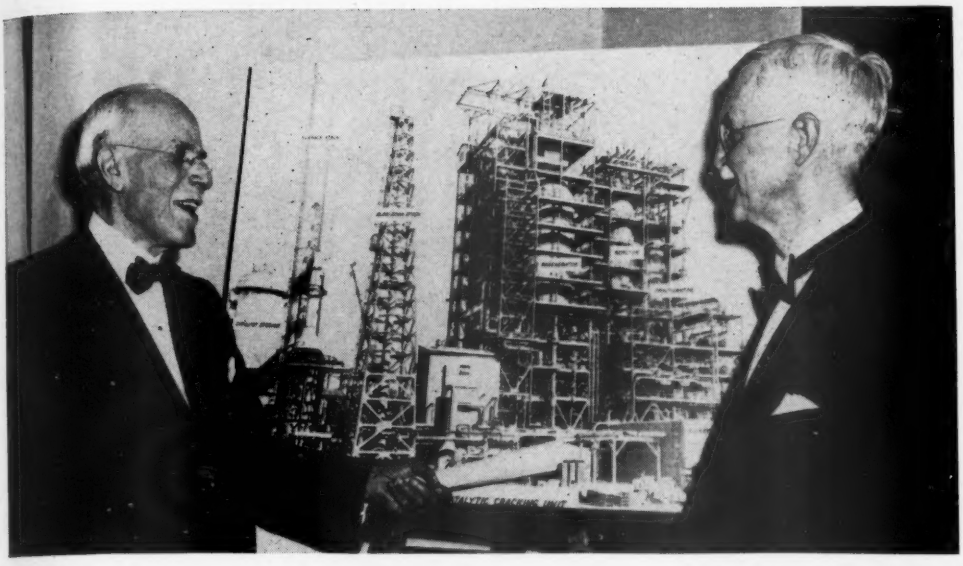
The still produced by operating at pressures of up to 95-100 psig and temperatures up to 750 F gave a "synthetic crude" from gas oil, with distillation ranges more or less equivalent to a natural crude. The gasoline and other products were separated by distillation in the then conventional equipment, with yields variously reported up to 15-30 per cent of gasoline, based on the charge. One great limitation on this process and its possible improvements was the lack of the tremendously improved steels of today. The still had to be caulked carefully, even then leaked when hot under pressure. The capacity of the first 12 Burtons was about 200 bbl each, run batchwise, so production was slow and limited.

Continuous cracking had caught the eye of technologists and experimenters, and a legion of researchers were going after data to perfect processes. Jenkins was at work on his steam boiler type still, with a stirring propeller to force circulation through a series of inclined tubes to prevent or minimize carbon deposition, bane of earlier shell type stills. Earlier the old Emersons, built like a Heine boiler without forced circulation had been tried with slight success. Fleming, with a vertical rather than horizontal shell, heated more than half the shell inside a brickwork "furnace"; in time the shell became potbellied from the continued heat and pressure on the long, rather large diameter cylinder. Innumerable other processes sprang up, to short and uneventful lives.

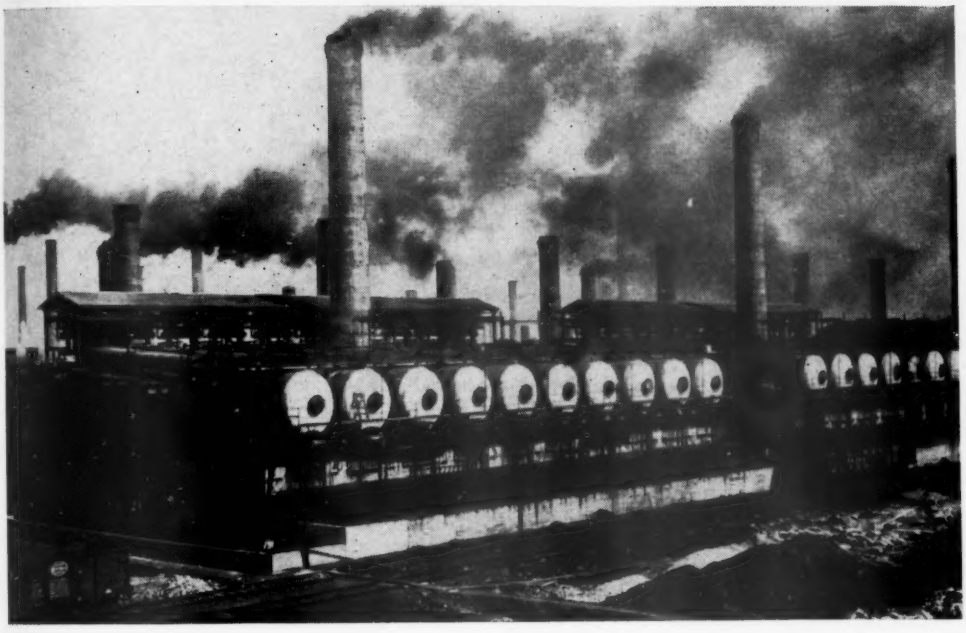
The Cross brothers began their historic study of continuous cracking, using a pipe or tube still, a continuous coil of horizontal tubes, either welded to bends at each end or screwed into the "return bends." Eventually Cross introduced the extremely heavy horizontal soaking drum, up to 5-6 ft diam, 30-40 ft long, and with walls of alloy steel up to about 5 in. thick; this drum was unheated externally. Unable to find an American fabricating company that would undertake the job of fabrication of the monster drums, Cross had the Krupp interests in Germany build them and ship them to this country. In time the well known Cross cracking unit evolved, one of the outstanding, successful processes of thermal cracking's heyday.

C. P. (Carbon Petroleum) Dubbs had begun his primary researches in continuous cracking, struggling as all did in those days, with inadequate knowledge of the properties of petroleum, with inadequate steels to withstand the conditions required, with inadequate funds to buy either steel, crude or workmen. The meat packer Armour came to his rescue, poured money into the venture and the outcome was Universal Oil Products Company and the Dubbs process. Everyone 50 years old or older remembers the famous and familiar elevated dephlegmators and the cracking chambers of the earlier Dubbs units, identifiable as far as vision extended.

Others were at work. The Holmes-Manley units as used by The Texas Company and others were largely the outcome of this Golden Age of cracking development. The so-called Tube-



Dr. W. M. Burton, left, pioneer in cracking development, standing with Dr. R. E. Humphreys, both early leaders in Standard of Indiana, before a photo of fluid catalytic cracking units, one of the recent developments in cracking oils.



Battery of early Burton cracking stills in the Whiting, Indiana, refinery of Standard of Indiana.

and-Tank units used largely by Jersey Standard and its affiliates, became efficient cracking tools. An interesting side line of the period of the 1930's is the history of cracking patent litigation, too voluminous to discuss here. Several units developed in greater or less degree than the few mentioned here, but these mentioned are the leaders.

Vapor phase cracking had meanwhile received considerable attention, but did not develop as rapidly as did the "liquid phase" processes mentioned above. Rittman did some vapor phase work about World War I. The Gyro process developed around the principles of vaporization of a distillate charge stock in a tube still, passing through reaction tubes at relatively low pressures of a few pounds, tubes into which earlier were inserted cylindrical "cores" of iron oxide as catalyst, the vapors passing through the annular space, thence to fractionation and/or condensation.

The TVP (True Vapor Phase) cracking process was installed in a few commercial units, but did not become a really important factor in thermal cracking. It employed the same principles as the Gyro except that no "catalyst" was employed at any time. Yields of both processes were fair, product was high in aromatics and in production of light olefins, ethylene, propylene, butylene, etc.

Eventually there evolved a general type of cracking process, called mixed-phase cracking, which routine was followed in general by practically all processes, and is so followed to the present. Actually temperatures may vary from 900 F to more than 1000 F, depending on the type of product wanted, the nature of the charge stock and other factors. Pressures may vary from 300 psig to about 1000 psig, in different operations.

Mention should be made of the so-called Winkler-Koch process, which it is understood was definitely a mixed-phase operation; it used no soaking drum in most units; it utilized a tandem two-coil system for a single charge stream, the first section heating the charge to reaction temperature, the second holding or "soaking" the charge at a desired temperature gradient to give the required degree of cracking.

As time went on two- and even three-coil operation was developed. In one coil a specific type of stock was cracked under conditions most suitable for that charge; in another a heavier, or lighter, stream of charge was cracked under other conditions, most suitable for its proper cracking. Generally these streams, when emerging from coil or soaker drum were combined for fractionation and/or condensation. It is this type of general operation normally employed in thermal crackers of today.

Evolution of Catalytic Cracking

Restless experimenters were contin-

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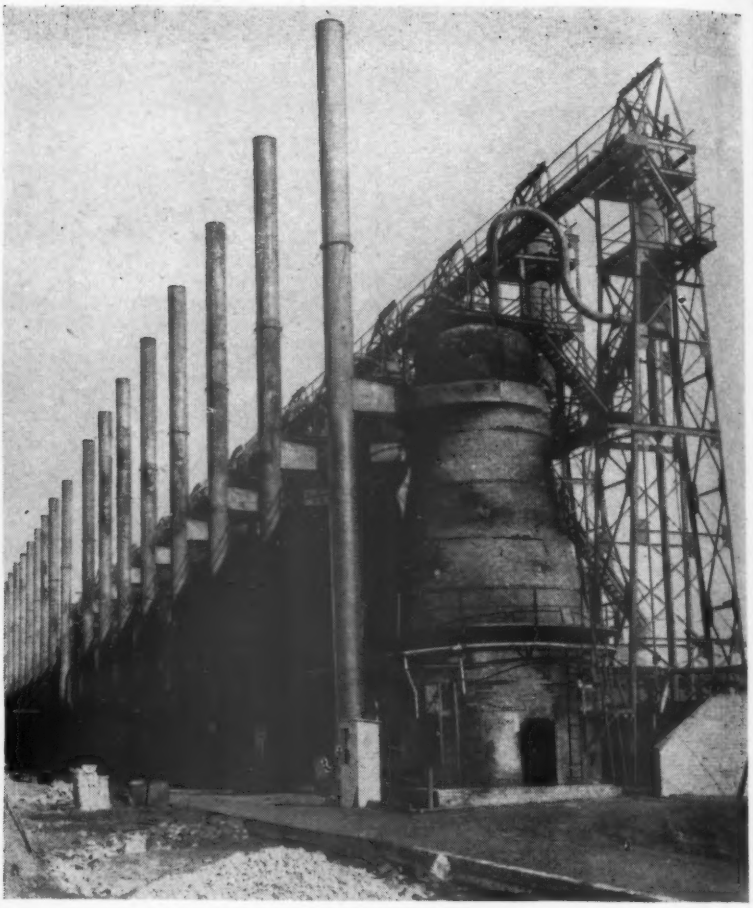
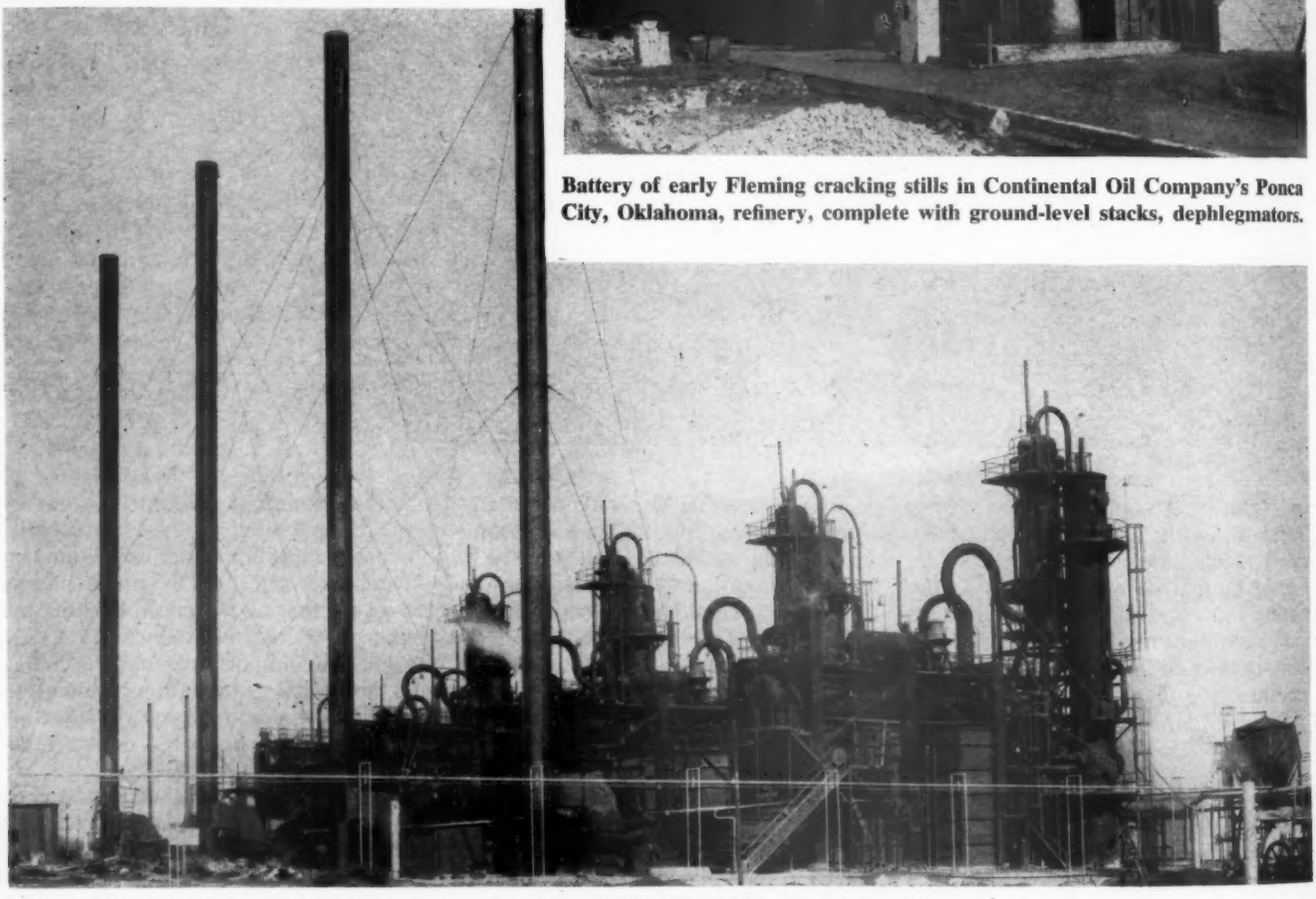
Early shell stills equipped with what were sometimes called "harps," or knock-back condensers, operating in an undisclosed Mid-Continent refinery.



Battery of early Fleming cracking stills in Continental Oil Company's Ponca City, Oklahoma, refinery, complete with ground-level stacks, dephlegmators.



Battery of four Jenkins cracking stills at refinery of Cosden Oil Corporation, Big Spring, Texas.

uing during the 1930's to tackle the job of applying catalysts to the decomposition of heavy hydrocarbons. It is said of the natural, inveterate researcher that, as soon as he has a given reaction under control and successful, he is through, has little interest in operating a commercial unit, is ready to go on to another unknown problem.

E. J. Houdry, a French scientist, began in a modest way to study catalysis of hydrocarbons in the late 1920's; came to this country in the early 1930's to obtain the funds and facilities to carry on and expand his work and with the aid of Socony-Vacuum Oil Company and Sun Oil Company developed the first commercially successful catalytic cracking process, the Houdry. Large-scale pilot plant work was under way in the Philadelphia area in the

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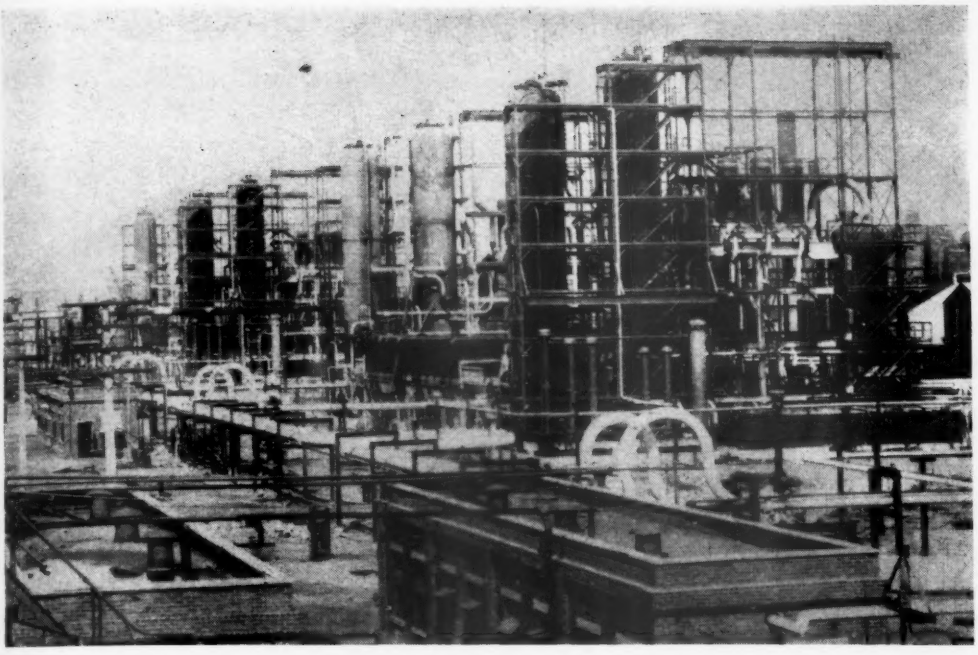
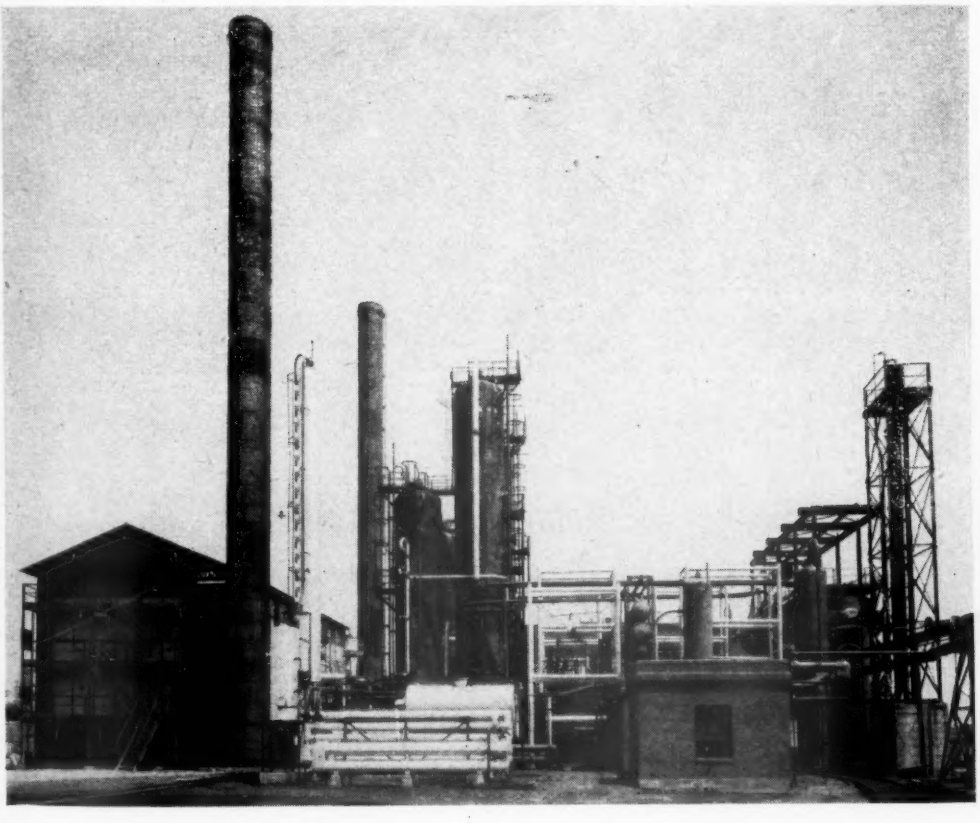


Large group of Tube-and-Tank cracking stills, one of the successful thermal processes of 20 years ago.

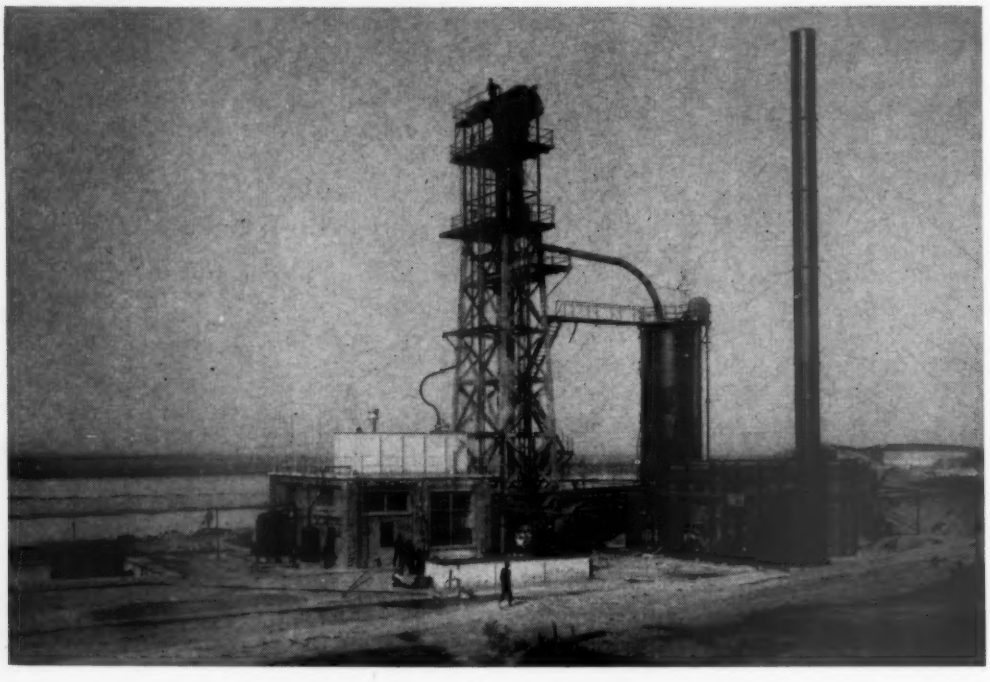
early 1930's, and the Houdry Process Company was organized. In 1938 before the American Petroleum Institute in Chicago, the first detailed report on the operation of this process was made to the industry by Arthur E. Pew, Sun Oil's vice-president for refining, representing the three-member group that developed it. Units were operating and building at Marcus Hook, and either building or planned for other refineries operated by members of the collaborating group.

Outstanding yields and properties were announced for process and product. Total yields were not as high as for recycle thermal unit operations, since these first units were on once-through cycle, giving some 40-45 per cent gasoline as of that day. Octane numbers were phenomenal, higher than any thermal process had produced. Strangely enough, too, definite variations in the hydrocarbon composition and octane rating of different portions of the motor fuel produced were shown. High aromatic content in the heavier end of the product made high octane ratings all along the distillation range. Large amounts of olefins were produced, useful for innumerable purposes in the mushrooming technology of the industry.

Catalytic cracking research had been begun earlier by a number of other refining companies and now efforts were were doubled and redoubled. At the same API meeting Universal Oil Products Company had announced a pilot-stage catalytic cracking unit that had as yet no commercial unit operating. Jersey Standard was working on small scale catalytic cracking experiments that eventually became the early fluid cracking process, which UOP,



Later design of the Cross cracking process unit, Continental Oil Company, Ponca City, Oklahoma.



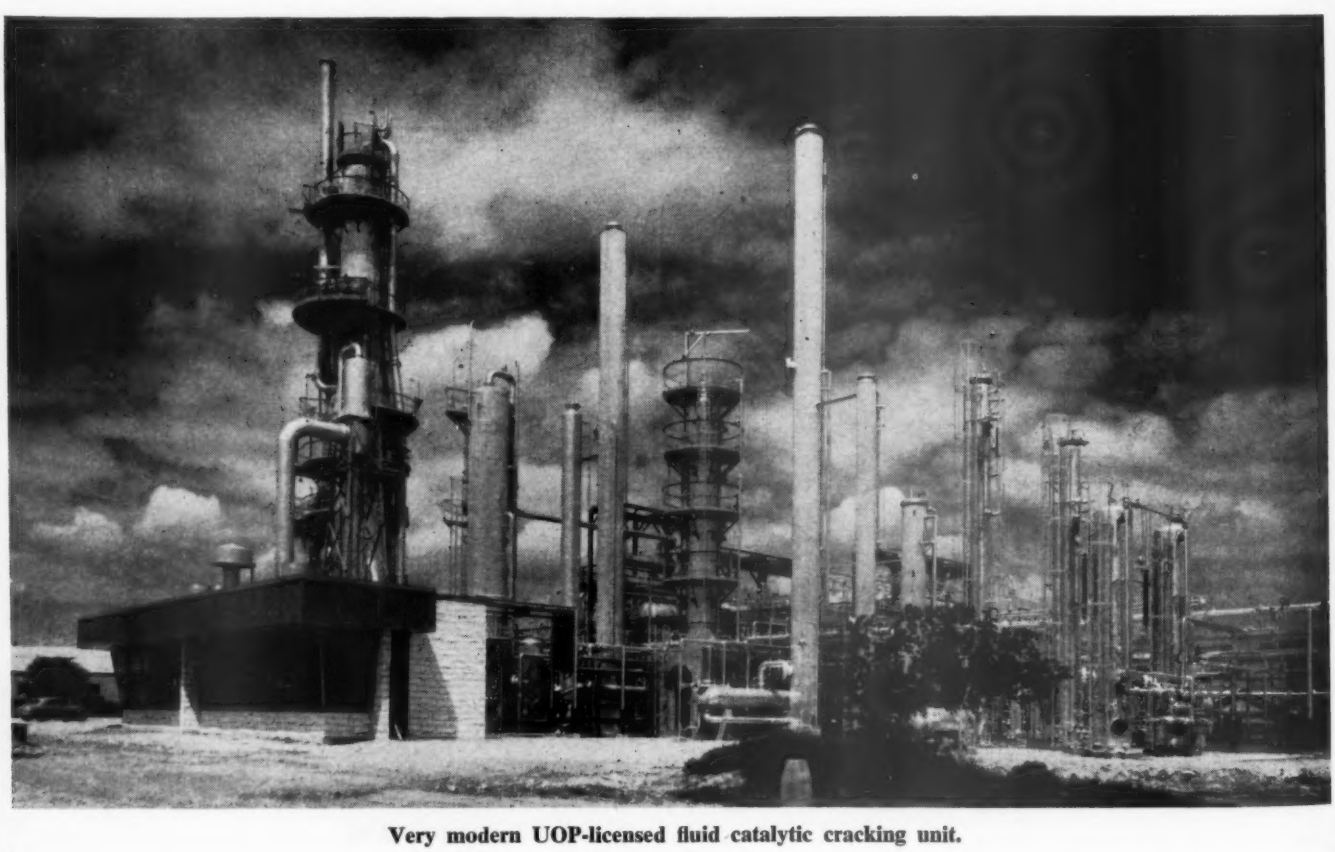
Ancient Dubbs unit of about 1928, in a Romanian refinery.

Jersey, and others shared in developing. Then, during the early stages of World War II ponderous "mountains" of steel were erected throughout the industry to supply the aviation and motor fuels needed by the Allied forces. Economics, as cat cracking technology improved, dictated that the fixed-bed cracker must give way to the so-called moving-bed and the fluid-bed type of operation.

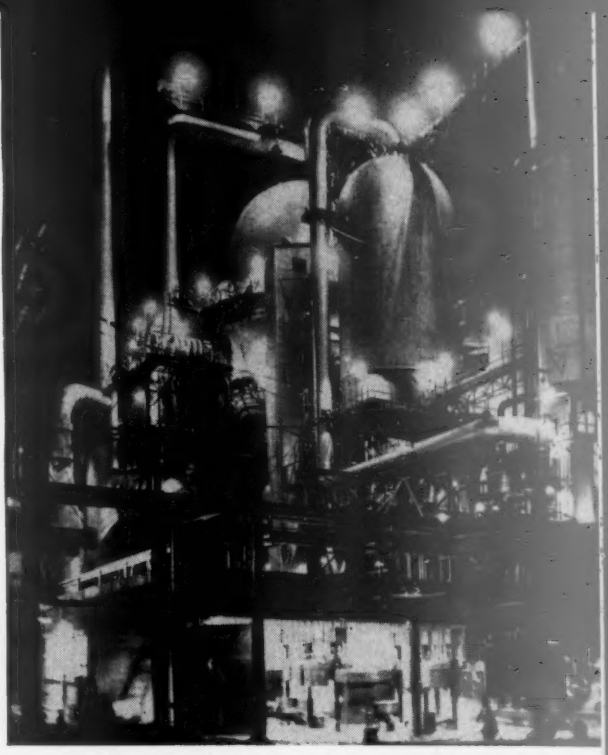
The Sun Oil Company and Socony-Vacuum went separate ways eventually in cracking development, Sun working largely with the Houdry group while Socony built the Thermofor cat cracking process around the Thermofor clay burning kiln, built originally to revivify filter clay.

This process first used what is called a moving-bed of catalyst; fresh catalyst is introduced into the top of a reaction vessel, into which the charge stock is also pumped in parallel flow. Catalyst moves down the vessel and is finally drawn, "spent," from the bottom after being stripped of vapors with steam. Cracked vapors are withdrawn and sent to the fractionator. The vapors are cracked in the vessel at up to 900 F or higher, temperatures varying with the purpose of the operation, and at 9-13 psig pressure as typical.

Originally the spent catalyst was hoisted to the top of the regenerator kiln by a chain of buckets, passed down the kiln to burn off carbon, was hoisted again via buckets to the top of the reactor, in a sort of "Figure 8"



Very modern UOP-licensed fluid catalytic cracking unit.



Wartime fluid catalytic cracking unit battery at Standard of New Jersey's Baton Rouge plant, left, dated 1944, rated at about 15,000-20,000 bbl per day. By contrast note the difference in height of main vessels fluid catalytic cracking unit, right, at Gulf Oil Corporation's Philadelphia refinery, on stream first this year. Capacity, 63,750 bbl per day of charge.

cycle. Later the Airlift design was developed, by which the reactor is placed above the regenerator, fresh catalyst drops into and through the reactor, passes direct to the kiln, and when it passes from the kiln bottom is lifted by air to the hopper above the reactor to complete the cycle.

Two types of catalyst are used; one a "natural" catalyst of silica and alumina, and one the synthetic "bead" catalyst, small spheres of 4-8 mesh containing in addition to alumina-silica a small percentage of chromic oxide to improve certain activities. Incidentally the catalysts in all processes are regenerated at controlled temperatures, varying from 1100 F to 1350 F, the latter value being prescribed for the TCC kiln.

The Fluid Catalytic cracking system is built in three designs, one termed the Orthoflow, another the Model 4 and a third known merely as fluid; these are designed mainly by Kellogg, Foster Wheeler, and UOP, respectively. A finely divided catalyst in either a carefully ground "dust" or as microspheres or minute spherical "beadlets," is carried by charge vapors forced in by a blower into the bottom section of the reactor, in which a thick bed of catalyst is maintained. The vapors pass up through this bed and cracked en route, passing out the top through cyclones that knock back most of the entrained catalyst. Vapors go to a fractionator, where those of the required volatility pass to a condenser, the heavier bottoms containing some catalyst fines are returned from the tower bottom of the cracking cycle.

In the Orthoflow design, (A) the reactor is placed above the regenerator as described above. In the (B) design the position of the two vessels is reversed, but in each case a single large vessel or tower is used; the earlier versions used separate vessels, the whole towering 200-225 ft into the air from base level.

Earlier Socony and Houdry Process Corporation had worked on the TCC design but parted company as mentioned above. Houdry forces worked out the Houdriflow design which also utilizes the single vessel with reactor on top and regenerator kiln below. A somewhat intricate system for stripping vapors from catalyst and for separating the two "streams" is employed at the reactor bottom, and the catalyst is regenerated in a manner somewhat analogous to that used for the TCC process.

Yields, conversion percentages, octane ratings, olefin production vary "across the board" with any of these processes, and are determined largely by the results wanted by the individual refiner. Conversions of 50 up to as high as 90 per cent of the charge are reported; Shamrock Oil & Gas Corporation has recovered 90 per cent of the charge in lighter products in its Houdriflow. Motor fuel component showing research octane ratings between 80 and 90 is produced, which can be "leaded" up to about 95 research method.

The above short descriptions give an inadequate picture of the present status of our 1954 catalytic cracking industry. As of January 1 of this year, our cat cracking capacity is 2,830,000 bbl per day of charge, as compared to 2,572,000 bbl daily for thermal cracking. The higher yields of useful products, hydrocarbon contents, and the 'useful' production of higher olefins give catalytic cracking right-of-way over thermal methods, although thermal cracking and reforming will continue to handle tough problems of refining and disposal of refractory byproduct fractions.

Thermal and Catalytic Reforming

The history of reforming of light, low-grade fractions parallels that of cracking heavier fractions. Thermal reforming was essentially a depression product of the 1930's. Imperative need for sales data in a period of dwindling consumption caused refiners to look about for any process that would improve their market conditions. Higher octane ratings were being demanded, the octane scale of measuring detonation properties having been adopted officially early in this period.

The major obstacle to higher octane ratings in the then existing limits and consumer demands for motor fuels was the low octane number straightrun naphthas, especially those from paraffin and mixed-base crudes; Pennsylvanian straightrun gasoline ran 50 octane number or lower, Mid-Continent fuel little better. Much of the octane advantage obtained from thermally cracking heavy stocks was lost in upgrading the straightrun naptha in the blend. The refiner could not afford to throw this low octane number fuel away. So, almost overnight thermal reforming came in, raising octane numbers to the 70-80 range, yields of 70-90 per cent of charge, operations car-

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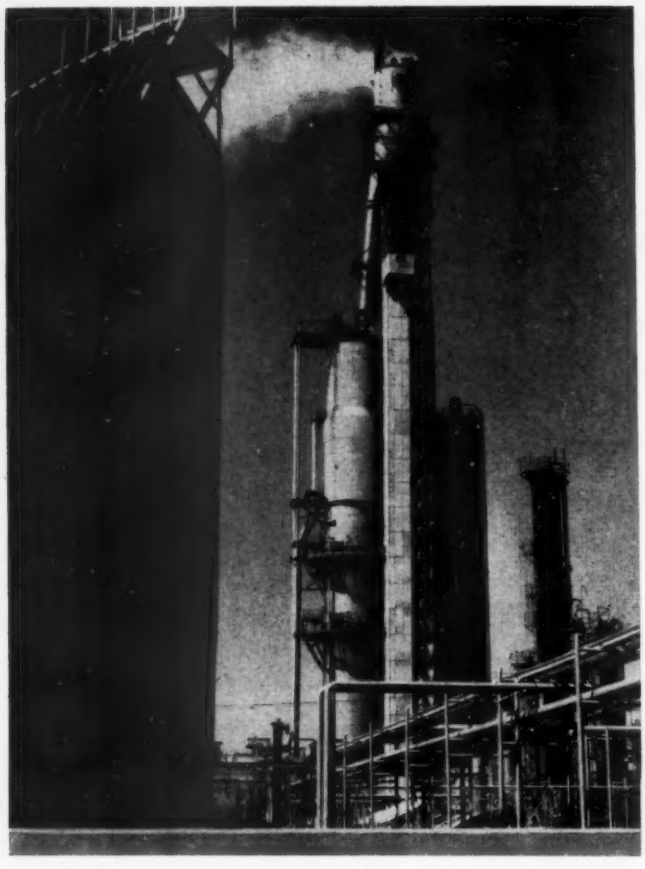
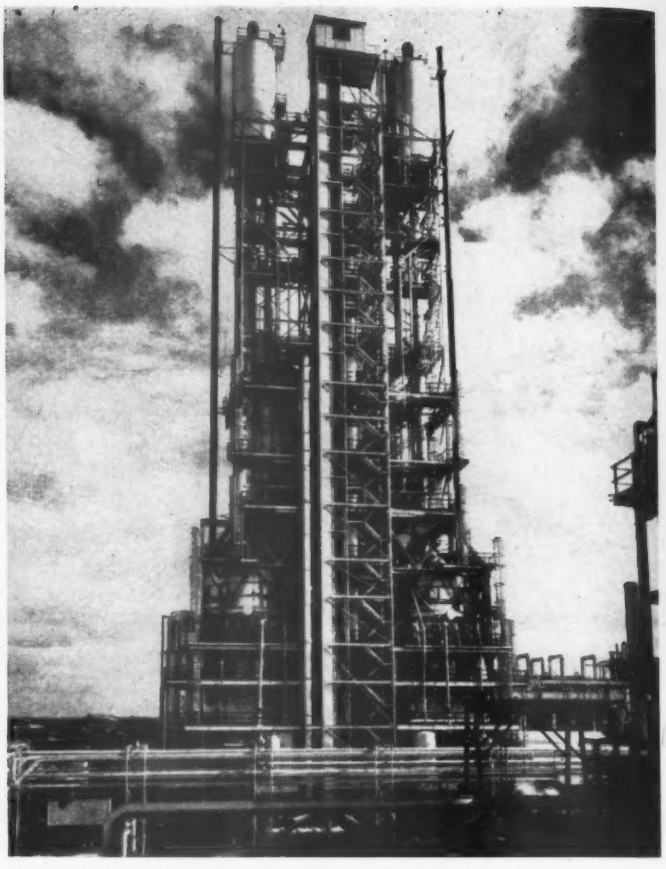


Newest design of Houdriflow unit at Texas City Refining Company.



New Airlift design of Thermofor catalytic cracking unit at plant of Magnolia Petroleum Company, Beaumont, Texas.

ried on at up to 1000 F temperatures or higher, pressures up to 1000 psig. The net result was the octane race, that is still being run, nowadays with renewed vigor.

Although several different general designs were developed for thermal reforming of naphthas, probably they do not vary so much as did the thermal cracking processes brought out in the 1930's. Like cracking, these units employed generally a soaking drum or chamber, tube still heater, and dephlegmators, knockout exchangers, and fractionating towers. Byproducts included heavy "synthetic" oil of the residual fuel type that might be sent to a recycle coil in a cracker or to heavy fuel tanks.

The charge was reformed under such conditions as to yield the octane rating needed, balancing the pros and cons of octane rating, per cent of gasoline, upkeep of the unit and market value of the product and of any byproducts. Thermal cracking was developed to increase gasoline yield on crude; reforming came in to improve quality not quantity of motor fuel.

Thermally cracked fuels from whatever process had higher gum content and often too much sulfur. Long were the verbal and even legal battles over the maximum sulfur content permissible in motor fuels. Eventually the increased use of tetraethyllead and the negative effect of sulfur on "lead susceptibility" has solved much of the problem, in favor of as low sulfur as is economically feasible. Cat cracking and reforming have solved it even better, by eliminating sulfur almost quantitatively during the main operation. But numerous methods for inhibiting and removing gum, including use of sulfuric acid and various oxidation processes finally won the day.

Just as cat cracking relegated the thermal operation to the handling of very refractory stocks in the majority of cases, so cat reforming has cleared the way to improved properties and better yields, results not attainable in satisfactory degree by purely thermal methods. Space will permit only brief mention of the several cat reforming processes developed recently, and of which about 250,000 bbl per day capacity was operating the first of this year. A large number of units are building, and the capacity is growing at a great rate.

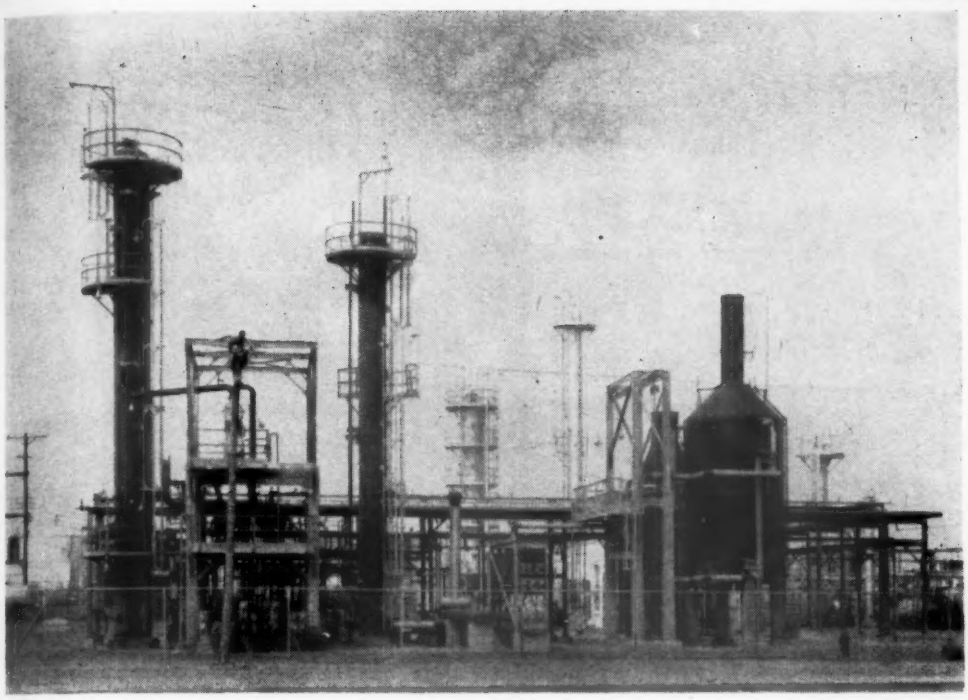
Among the cat reforming processes in use are Catforming, Atlantic Refining; Cycloversion, Phillips Petroleum; Houdriforming, Houdry Process; Fluid Hydroforming, Kellogg, et al; Hyperforming, Union Oil; Platforming, Universal; Sinclair-Baker Reforming, Sinclair Refining and Baker Chemical; T. C. Reforming, Socony-Vacuum, and Ultraforming, Standard of Indiana.

Briefly, Catforming is done with a catalyst said to contain some platinum metal; reports more than 100 volume percent of gasoline (including natural gasoline added for volatility), of 86 octane number with two cc of TEL practically sulfur-free from a 0.10 per cent sulfur charge. Like other units this process employs two or more reactors, fixed-bed, with reheaters between, hydrogen-rich gas being compressed and circulated with the charge, to reduce carbon deposition, etc.

Cycloversion, next-to-oldest of the processes, uses a bauxite catalyst of 5000-20,000 bbl per ton catalyst life, reforms gasoline in 80-90 per cent yield; desulfurizes naphtha or diesel fuel stocks with up to 98-99 per cent yields. It is used also to crack gas oils for 92-95 octane number with 3 cc TEL.

Houdriforming is carried out with a company-manufactured platinum-concontaining catalyst in multiple reactors with intermediate reheat, at 875-950 F reactor temperature, 250-600 psig pressures and 4-10 hydrogen-oil mole ratios, with yields from 80 to more than 90 per cent of naphtha charge.

Hydroforming is the oldest of the existing reformer processes, being in operation in a half-dozen fixed catalyst

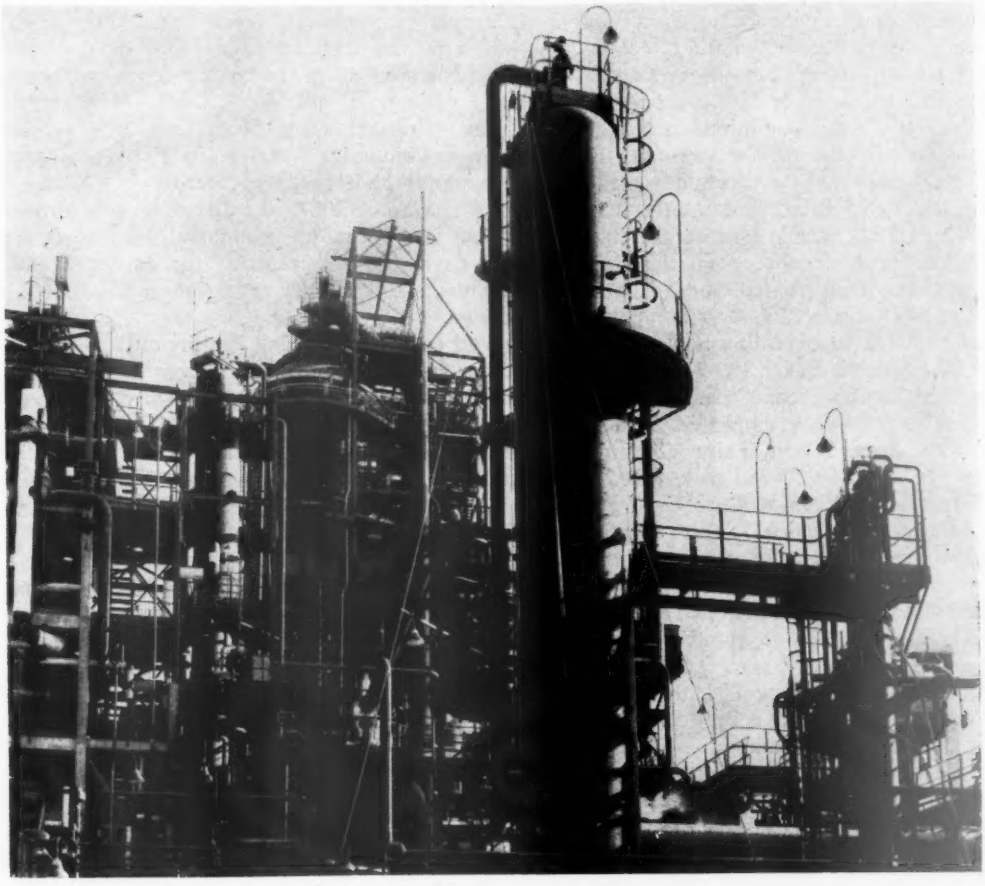


Recent "midget" Platformer unit operating at Onyx Refining Company, Central Texas.

bed units prior to the World War II; from these units more than half the benzene, toluene, xylenes, etc. were obtained for war uses. The recent application of fluid bed operation has rejuvenated the process economically and improved product quality. The catalyst is made of metallic oxides including molybdenum oxide, with no platinum so far as has been announced. Catalyst is regenerated at about 1100 F top temperature to avoid damage to it.

Hyperforming utilizes a cobalt-molybdate catalyst at some 400 psig and 800-900 F reactor temperature, regenerates the catalyst in the Hyperflow air-lift line, with 2 per cent or so of oxygen in the air-flue gas lifting medium. Catalyst circulation rate is low; 5 tons or less per hour for a 10,000 bbl per day unit. A 385 F endpoint naphtha has its octane rating raised from 63-plus-3cc-TEL to 95-96-plus-3cc-TEL.

Platforming is the process most widely installed in the industry the oldest of the post-war developed processes. As its name indicates its catalyst contains platinum metal, and is not



Catforming unit of Atlantic Refining Company at Philadelphia, Pennsylvania, placed on stream late in 1953, to make 500,000 gal of Catformate daily.

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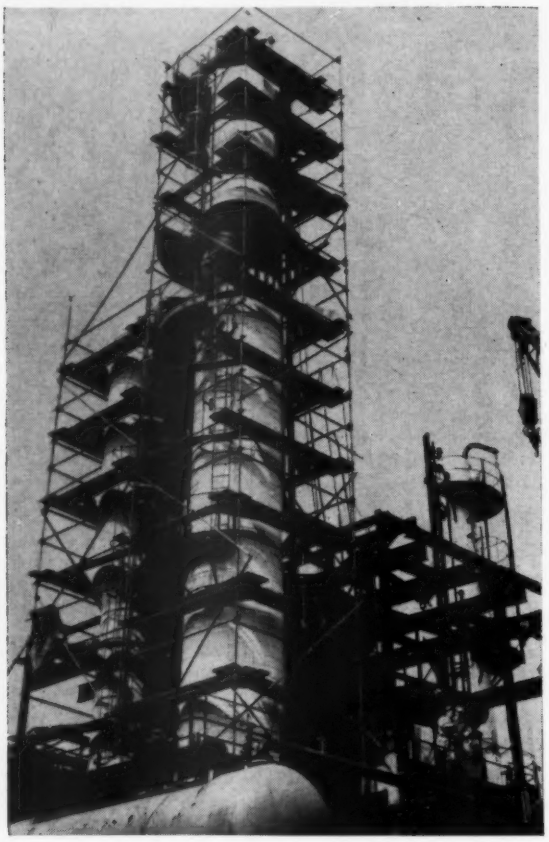
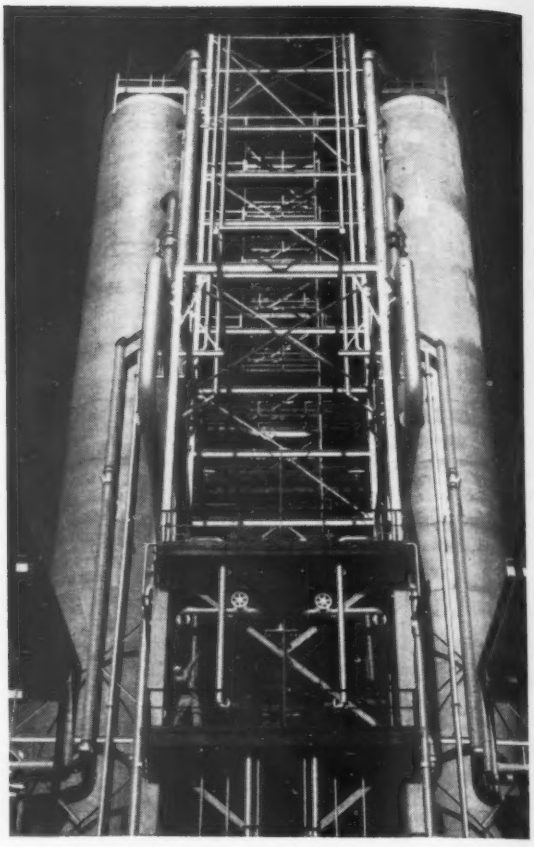


Catalytic polymerization unit placed on stream recently by Gulf Oil Corporation at its Philadelphia, Pennsylvania, plant will make 2800 bbl per day of gasoline blending stock, from unsaturated refinery gases.



Twin vacuum distillation towers at Cit-Con Oil Corporation lubricating oil refinery at Lake Charles, Louisiana, used to distill off lubricant fractions.

regenerated in situ like most of the other catalysts.

It is used widely — all cat reformers are so used — in making both improved motor and aviation fuel components and to produce aromatics and olefins for petrochemical intermediates. It is a multiple-reactor-with-reheat system, operating at 200-700 psig and 850-960 F, the conditions being determined by the product wanted. For motor fuel the platformate makes up to 93-100 F-1 octane number with 3 cc of TEL. Yields range from 80 to 90 per cent, depending on the stock and the product wanted. Some 80 units have been licensed here and abroad, with nearly 40 operating now.

The Sinclair-Baker RD-150 catalyst is used in that process, contains platinum, and may be employed with or without regeneration in situ. The process operates at 200-750 psig, 850-970 F reactor inlet temperature, 3-10 gas-to-charge mole ratios. With product of 85 research octane number, yields range from 96 to 102 volume per cent, including light material added for volatility. At 95 octane number, yields range from 84 to 95 per cent on the same basis. With 3 cc TEL the 95 octane number product is brought to 100 or higher octane number.

Thermofor catalytic reforming process uses a chromia-alumina gel bead catalyst and employs the circulating bed principle, analogous to the TCC process for heavier charge stocks. Operating conditions may vary widely, but typical are 175 psig and up to 1000 F, as when running to make 100 octane number reformate with 3 cc of TEL. Hydrogen-rich gas up to 6 gas-to-charge mole ratio is circulated. Catalyst is regenerated in a thermofor type kiln.

The Ultraforming process uses a platinum-containing catalyst in fixed beds, but regenerates it cyclically in situ. Pressure of 200-500 psig are employed, and a "unique technique" has been developed for restoring the catalyst to its full activity rating at each regeneration, in which a swing reactor is used to make the unit continuous. Octane ratings obtained range from 85 to 100 depending on the stock reformed and the severity of operation. At 500 psig, yields range from 100 at 85 octane number to 86 at 95 octane number.

The foregoing gives in very brief facts the essentials of the revolutionary developments in the reforming of low-grade naphthas by thermal and by catalytic means. The tremendous advantages of the catalytic operations are obvious, and that system is expected to increase capacity at very rapid rates at the expense of less and less thermal reforming.

Actually, the catalytic method for either cracking or reforming has given the refiner tools by which he can control the type and quality of products over a very wide range, in products of greater and greater efficiency and usefulness.

Catalytic Polymerization, Alkylation, Isomerization, Etc.

As with cracking and reforming, thermal (heat plus pressure) methods for the polymerization of olefins was worked out in a measure before catalytic methods came to the fore. As has been usual, the catalytic methods have proved to be best both technically and economically.

Back in the late 1920's and early '30's Pure Oil, Atlantic Refining and other refining companies worked assiduously at polymerizing olefins such as propene, butenes, etc., under elevated temperatures and pressures, up to 1000 psig or higher and up to 900-1000 F. Several thermal 'poly' units were built and operated, to pass out of the picture long since, so far as we know. These olefins are to the refinery what the refuse meat products are to the packer, from which latter the meat packer makes fertilizer, etc. Almost it may be said that olefins are the 'squeal' of the refinery output.

In the early 1930's, Universal Oil Products Company began research and came up with the catalytic polymerization process, long since almost universally used in the industry. This process uses a phosphoric acid catalyst carried on a solid support such as mag-

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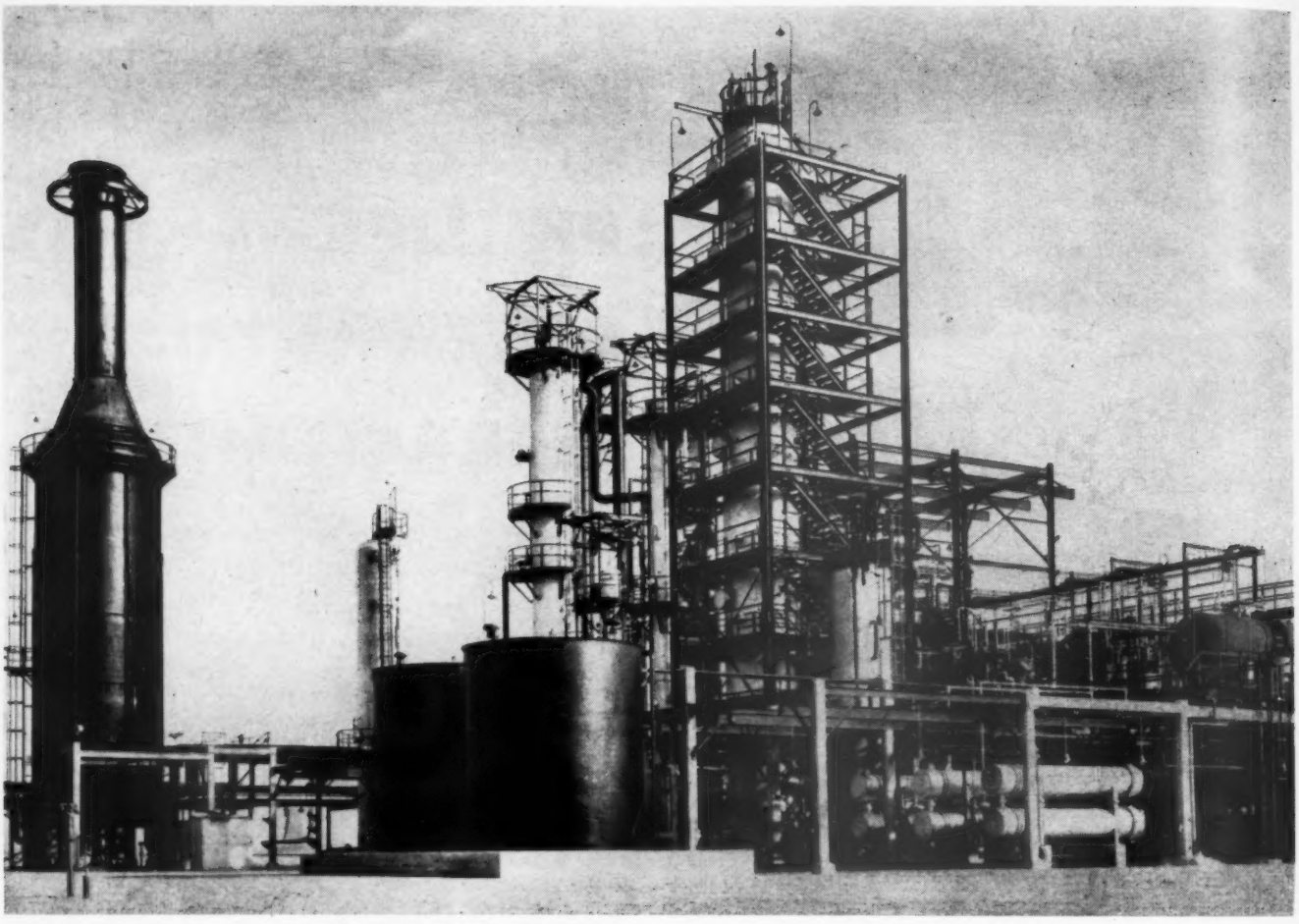


Furfural solvent extraction unit, the first in the world installed to refine diesel fuels and home heating oils, at Texas Company's New Jersey refinery.

nesium sulfate; for the first time this routine did two things; it enabled the refiner to conserve crude by increasing his motor fuel yield by 1 to 4 per cent; it gave him an invaluable blending polymer the "blending value" of which was 110 to 130 octane number. Both advantages meant an important step forward in refining economics. An indirect advance was the boost given to the use of catalysis in refining processes.

At first these units were built only in relatively large units, for what were considered sound economic reasons. In a short time, however, small units, "midget" poly plants were built and operated economically in Michigan, where high octane blending polymer was at more than a premum. This discovery that small units would pay out raised the number of plants that could use the process satisfactorily from about 40 to more than 135. The process first operated in the vapor phase largely, but later temperatures were raised to 400 F or higher. Pressures were raised to maintain the charge of propene-butene in liquid form and the charge was pumped through the chambers as liquid, improving both yield and product, reducing the size and the cost of the equipment.

Kellogg Company also developed a polymerization process employing a pyrophosphate salt as catalyst, under more or less the same conditions. Several plants were built and operated over a long period.

Alkylation of isoparaffins with olefins came into the limelight in the mid-30's by the work of the great Russian-American research leader Ipatieff, and of others. Ipatieff contended isoparaffins were reactive, contrary to popular notion. He proved it by reacting olefins such as butenes with isobutane to form a mixture of isooctanes. Standard Oil Development, Kellogg, etc., developed the use of sulfuric acid as catalyst and by the time World War II broke out a number of alkylation units were synthesizing isooctane for use largely in aviation fuels for reciprocating engines, to boost octane ratings for the new engines.

Yields ran 150-200 weight per cent based on olefin charge; octane rating 91-96 or thereabouts.

As the 1942 war cloud descended UOP and Phillips Petroleum were working separately on hydrogen fluoride, anhydrous, as an alkylating catalyst. War needs induced these two companies to collaborate with result that a large number of HF alkylation units were built and by war's end were turning out large amounts of alkylate for aviation fuels. The products of the two processes have about the same octane blending value, although differing in percentages of individual components. Voorhees[1] gives figures to show the comparative percentages of the main components of the products made by the two processes:

2,2,4-trimethylpentane (Isooctane)	H_2SO_4 26.7 vol %	HF 41.7 vol %
2,2,3-trimethylpentane	1.3	21.9
2,3,3-trimethylpentane	13.5	10.0
2,3,4-trimethylpentane	14.3	9.4
Dimethyl hexanes	11.2	19.6

As of today cat cracked and cat treated gasoline and aviation alkylate form the greater part of military and civilian aviation fuels. This fuel is a far cry indeed from the straightrun, acid-treated 50-to-70 octane rating of the aviation fuel of the first World War (octane rating was not thought of in 1917-19).

In the alkylation procedure, to avoid or minimize polymerization of the olefin, the normal charge may contain three to six times as much isobutane as olefin, to 'dilute' the olefin to induce it to react with the paraffin rather than

[1]The Petroleum Engineer, February 1954, p. C-32.

polymerize with itself. A third means of obtaining isooctanes and other isoparaffins for aviation gas is to polymerize selectively butenes with phosphoric acid or other catalyst, at 300-350 F and 900 psig, to yield largely isooctanes, called "codimer," which are hydrogenated at high temperatures and pressures to give isooctanes predominantly, known as hydrocodimer, of 95-100 octane rating.

Lube Refining Advances

No segment of refining processing shows greater contrast between the 1920's and the 1950's than does the comparison of the methods employed for lubricating oil refining then and now. Typical operations then were atmospheric fire-and-steam distillation of the lube fractions using large quantities of steam to take the heavy oil overhead, until no more could be distilled without heavy cracking. The undistilled portion was pumped from the still, was filtered heavily in Pennsylvania, acid-treated and filtered in the Mid-Continent and elsewhere.

If a wax-bearing crude the wax in the heavy residue, after filtration and/or acid-treating, was crystallized by chilling in tanks and settled out in settling tanks and the supernatant oil was drawn off to obtain a product of a given pour point, usually high in terms of 1954 lubricating oils. Earth filtration was done on this at elevated temperatures by the percolation method through cylinders containing several tons of fuller's earth or other "filter clays." The heavy stock was normally diluted with naphtha to speed up filtration rates. Later wax was removed by the Sharples-Miller super-centrifuge system, a great advance.

The "bright stock" so refined might receive still another clarifying filtration, or might not, as the refiner found advantageous. It was stored to blend back with the "neutral oil" fractions distilled overhead.

Neutral oils, in two or more fractions, light, heavy, etc., were chilled until the contained paraffin wax, usually more crystallizable to filterable crystal size than the bright stock, solidified and this wax removed in heavy wax presses to obtain oil of low enough pour point. "Clay" filtration followed the routine of bright stock, without naphtha dilution. Two or more neutral fractions were blended with varying ratios of bright stock to make the finished oils of required viscosities.

During the 1930's two major types of process came into lube refining; solvent, dewaxing, and selective solvent extraction. Each was based on the differences in solubility of various hydrocarbons in one or more solvents.

The first major process for selective extraction employed liquefied sulfur dioxide, SO_2, a highly selective, low capacity solvent that separates aromatic-asphaltic type hydrocarbons very efficiently from paraffinic types. This process was developed first in Germany for treating, not heavy, but kerosine-type oils, by Dr. Edeleanu and is referred to as the Edeleanu process. By its use, as with other solvents, the high viscosity-index parts of the lube distillate or residual oil were separated as raffinate, the unstable, low viscosity-index aromatics and asphaltic constituents were removed as extract, to be used as cracking stock or any other purpose.

The raffinate might be filtered to improve color and other properties, redistilled to more desirable distillation range (volatility) and blended to obtain the required viscosity range.

The purpose of all selective solvents is the same, essentially. At one time at least seven solvents were in use for this purpose; SO_2, nitrobenzene, Chlorex, phenol (carbolic acid), furfural, crotonaldehyde and the Duo-Sol Selecto solvent (cresols). Each solvent had certain advantages; one was more selective against carbon depositing components; another had a high extract-carrying capacity, still another, SO_2 especially, was highly selective, that is, "choosy" in removing one type of component without picking up much of that wanted as lubricant, and so on. Duo-Sol used two immiscible solvents, liquid propane as a solvent for paraffinic oils, and so-called Selecto as aromatic-asphaltic solvent.

As of today, furfural, phenol, and Duo-Sol are the remaining processes quite active and used widely in the industry. Altogether these three refine the huge percentage of lubricating oils, almost the industry's entire production. A few refineries do not use solvents but the amount of lubricating oil they produce is somewhat negligible so far as quantity is concerned.

In addition to the quality improvement made by judicious extraction methods more recently the use of generally non-petroleum additives has become widespread. Film strength agents to improve the ability to hold a film of oil between journal and bearing under severe conditions: anti-oxidants to prevent oxidation-decomposition of the oil in service; detergents to keep sludge and non-lubricant products formed in the engine in suspension-solution in the oil, prevent deposition in the engine; viscosity-index improvers; pour point depressants, the last to reduce the temperature at which paraffin-based oil will cease to pour or flow. All these have boosted the overall quality of modern oils and have evolutionized lube oil manufacture.

Fuel Oils and Diesel Fuels

In no phase of refining has greater changes taken place, affecting economics and ultimate disposal as well, than in fuel oils, distillate and residual. In the 1920's heavy residual fuel was just beginning to be adopted widely by the railroads for steam locomotive fuel. Eventually west of the Mississippi River no railroad steam was generated by coal and the residual fuel from thermal cracking, used by the locomotives, made the difference between profit and bankruptcy for the refiner. The reasons for its use over coal were obvious and conclusive. Then along came General Motors with its Electro-Motive Corporation affiliate, adapting the economical diesel engine harnessed to an electric motor-generator set, for railroad locomotive power. Various troubles were encountered and solved finally, troubles traceable to both fuel deposits and lubrication difficulties.

The outcome is that few steam locomotives are being built, most of those in operation are for short-haul freight trains or for yard work. Two years ago, of more than 300 locomotives on order only about 6 were steam, oil, or coal fired, the remaining 98 per cent being diesel-electrics.

The high economy plus the operating flexibility and the excess power that can be built into a diesel-electric unit simply rules out the familiar steam chugger, long the symbol of railroad power, that is going surely the route of the dinosaur and the pterodactyl.

A quarter-centry ago all diesels with a few exceptions were slow-speed stationary, operating at 60-150 rpm ponderous, 10 to 50 lb weight per horsepower, burning anything from powdered coal to kerosine. As of the present the major groups of diesels are two, the medium-speed locomotive diesel using a middle distillate "on the heavy side", and the high-speed automotive diesel which competes successfully with the gasoline motor on the highways, mainly in trucks and buses, that uses clean, light distillate heavier than kerosine but higher in gravity than locomotive diesel fuels, normally.

Signal advances in making diesel fuels follow three routes; additives that improve cetane number, chemicals such as the organic nitrites and nitrates, and several other types, that speed up the rate of ignition and combustion of the fuel charge and thus shorten the ignition time-lag and promote efficiency. Cetane number measures the speed of ignition of diesel fuel after injection into the combustion chamber; the shorter this time-lag the more efficient the fuel. The second main route to better diesel fuels is by the use of selective solvents. It operates on the same principles as that of refining lubri-

XUM

cants, removing the aromatic-asphaltic components of the fraction of crude and leaving the more paraffinic portion that shows a higher cetane number as the diesel fuel.

The third method is by hydrogenating less paraffinic fuels to make them more paraffinic and thus of higher cetane number. Any treatment given to any petroleum fraction raises its cost and thus its market price. With the great number of uses to which crude fractions may be put the extract from diesel fuel solvent refining finds ready outlet in catalytic cracking stock, as domestic distillate heating oil, or for other uses.

The yield of top-quality diesel fuel by this route is determined by the cetane number called for and by the percentage of that quality found in the raw stock refined. Some refiners are employing such solvents as furfural to make premium diesel fuel in quantity. Thus, technically speaking, the cetane number quality of diesel fuel is under the direct control of the refiner, although cost increases limit the improvement that is economic.

Some picture of the trend in railroad power sources is shown by recent figures published by Standard of California. In a period of only 7 years (1946-53), use of coal for locomotive use dropped from 110,000,000 tons to 28,000,000 tons annually, down 74.5 per cent. Use of residual fuel dropped from 275,000 bbl per day to 76,000 bbl per day, or a market loss of 72 per cent.

During the same period consumption of diesel fuel by railroads rose from 48,000 bbl per day to 205,000 bbl per day. The loss of 199,000 bbl of heavy fuel oil, plus the loss of 82,000,000 tons per year (225,000 tons per day) of coal is replaced by only 157,000 bbl per day increase in diesel fuel consumption.

This difference, roughly, may be considered a measure of the relative efficiency of the diesel and its fuel. Obviously the price of diesel fuel is higher than either of the other fuels, so diesel's economic efficiency is less than is indicated by the comparison of these quantities, yet is still quite high.

Jet Fuels

The impact of the introduction of jet engines and their fuel requirements on the refiner's economy is probably not yet fully understood by the huge majority of the members of the industry. No comparison of then and now for jet fuels can be made, since such a fuel was totally unknown and undreamed-of in the 1920's. Briefly, jet fuel becomes a sort of heavy gasoline-light kerosine blend, with various requirements that as time goes on are being made more stringent.

Main items in the JP-4 specification, (understood now to be obsolete), are: freezing point, minus 76 F; gum, 10 mg/100 ml; aromatics, 25 vol per cent max; total sulfur, 0.4 per cent; gravity, 40-58; vapor pressure, 2-3 lb Reid; distillation, 10 per cent, 250 F; EP, 550 F; Bromine No. 30 min; heat of combustion, btu/lb 18,400 min, etc. These values have been changed widely, and are given merely to represent one set of specifications in use at one time.

In 1952 the military establishment of the U. S. A. consumed 100,000 bbl of all types of jet fuels daily. It was then estimated that under refinery operations and capacity of that time, when 70 refiners were making jet fuels, the effect of production of 60 per cent of the total JP-4 jet fuel needed under "all-out" (war) conditions would reduce the quantity of motor gasoline procurable by about one-third.

When making "all-out" jet fuel requirements in 1952, the amount of gasoline obtainable would have been reduced to about 50 per cent. That is, the country must get along, for both military and civilian use on half the motor fuel supply that could be made for peacetime consumption!

Similarly, 60 per cent of the maximum jet fuel needed would reduce the production of kerosine by more than half. Full jet fuel production estimated for all-out war needs would reduce kerosine production to about one-fourth of normal.

What Is To Come In Refining?

In spite of all the data on present and past that the observer can collect, prognostication is risky business; witness the various presidential election polls that have gone "haywire" in the past. Yet the two main tools for the refiners' uses that are practically certain to be the main batteries for attack on the problems of making required products are: Change in chemical constitution of hydrocarbons by the numerous processes available and to be developed in future; and segregation (fractionation) of hydrocarbon types for any given purpose, separating them from those types not wanted in a given product. On these two principles "hang all the law and the profits", that is, the law of survival of the individual refiner, and of the industry.

Passing over, for the time, the mushrooming petrochemical industry that, while large in the economic phase of refining still will consume only very small percentages of crude and natural gas hydrocarbons (petrochemicals are discussed elsewhere in this publication), catalytic methods are expected to continue in number and importance for all phases of the industry, a rather obvious conclusion. More and more, less desirable hydrocarbons will be rearranged in molecular structure and weight, to make those types more suitable for individual purposes. More and more, our products will be synthesized or "tailored to fit" the end-use.

That diesel-type power consumption of especially "middle of the barrel" fractions will continue to mount is also self-evident. A great and primary question that must be answered repeatedly by the refining industry and its customers is that of the relative efficiency of use of different fractions, especially the heavier-than-gasoline portions of the crude. Costs mount when "gas oil" fractions are converted to motor fuels. These same fractions, or a good part of them, can be burned very efficiently in diesel engines, either as such or after relatively simple and inexpensive treating to improve cetane number, etc.

The question arises: will the overall use-efficiency of gasoline pay for the added cost of cat cracking, etc. to make the motor fuel from gas oils? If not, then eventually it is inevitable that the lower-cost fuel will be used as is, rather than to add more cost that cannot be paid for by the added efficiency.

Charles (Boss Ket.) Kettering once said that the diesel cycle can be made to do anything the gasoline engine will do, and do it better, or words to that effect. To date the gasoline engine and its fuel present a more flexible power plant for the use of automobile and truck users, than is available in diesel engines. Yet diesel power is being applied more and more rapidly to drive trucks, buses, tractors, where the individual operator is willing to go along with certain inconveniences in starting, in weight, in fuel availability in order to obtain the added efficiency and maximum power.

Conversion of airplanes to jet power —England already has a line of jets flying as commercial planes, and jets are being readied for planes here—will change the picture of internal combustion engine fuel production in just the degree that jet fuels replace conventional high octane number fuels, though not in direct quantity proportions.

Jet fuels still will use some of the raw materials that are cracked or reformed now for conventional "light" fuels; the efficiency of the jet engine is now far inferior to that of the spark-ignition and the compression-ignition (diesel) engines. Alkylation units now devoted largely to aviation fuel production may turn out high octane number blending fuel component to boost the unleaded rating of motor fuels to aid the eternal octane race now plaguing refining economics of the industry.

Whatever the details of development

in future, the refiner's product battle will be still for the middle of the barrel, the kerosine, stove oil, gas oil, lubricant portions of the crude. As this battle rages unabated refiners and users alike will make strenuous efforts to utilize from other fractions the products that can be applied to their needs that are now satisfied by products from that middle of the barrel, and so promote both their and the refiner's economy.

Utilization of light hydrocarbons, butane and lighter, will be accomplished by processes analogous to the Fischer-Tropsch synthesis of heavier hydrocarbons from methane and ethane, etc.; by isomerization and alkylation and such methods. Conversion of the inevitable though dwindling output of heavy residual oils to gasoline and heavier via hydrogenation, etc., is another of the methods for solution of that growing headache, that in one form or another will go along to a positive conclusion. * * *

Plant Aid

Ever Anchor Tite Gage Saver†

W. F. KNIGHTEN, JR.*

This method is intended for the determination of the vapor pressure of liquified petroleum gas products to be used only for routine plant control testing. The modification is designed to protect the vapor pressure gauge and to facilitate and expedite the sampling of the product. The test gage is left in the laboratory while securing the sample in the vapor pressure bomb and is attached to the bomb when sample is brought into the laboratory, results being less replacement or repair for test gages, labor, time, and money saved by use of Ever Tite Coupling and Adapter.

The Ever Tite Coupler at sampling location is connected to Adapter on bomb. When sample is secured and valves on bomb are closed, pressure on hose os released by opening ¼-in. pressure relief valve. The coupler is uncoupled and bomb is brought into laboratory after outage is secured. Ever Tite Coupler on gage is coupled to adapter on bomb and ¼-in. needle valve is opened to allow pressure on gage. All other procedures not mentioned are followed as outlined in Technical Standards of the National Gasoline Association of America.

The Ever Anchor Tite Gauge Saver has been in use for approximately five months at the United Gas Pipe Line Company, Carthage Gasoline Plant, Carthage, Texas, for testing the vapor pressure of No. 1 plant propane stream.

*United Gas Pipe Line Company, Carthage, Texas.
†Class B, honorable mention, NGAA Kinks Contest.

Plant Aid

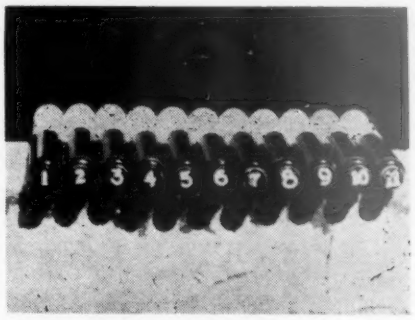
Charcoal Tube Identification

DON ATTAWAY*

In making field charcoal gpm tests, the tester often has any number of tubes, both saturated and unsaturated in his possession. Quite often confusion results identifying the individual samples. At the same time, an unmarked and plain tube cannot be readily checked without one end or the other which does not benefit a saturated sample and sometimes results in spillage of the charcoal.

It is proposed that each charcoal tube be painted an identifying color, preferably black and white. The lower section, containing the screen or grid for retaining the charcoal, as well as the cap should be painted black and numbered. The upper section and cap should be painted white. As long as the tube is unused the proper color cap will be on the proper color section.

When the tube has been exposed or saturated, the tester notes the tube number on the slip of paper bearing test data which is placed in the screen end of the tube and the caps reversed. This places the black cap on the white end and the white cap on the black end signifying the saturated sample. The tube number on the cap identifiies the test.



Markings for easy tube identification

Through this color identification system, unnecessary opening of the tube is prevented and charcoal samples are easily identified in the laboratory. At the same time, the screen end of the tube is easily recognized and spillage of the charcoal sample eliminated.

*Arkansas Fuel Oil Company, Shreveport, Louisiana.
†Class B, honorable mention, NGAA Kink Contest.

Eliminate Liquid Trap in Coil Outlet Headers‡

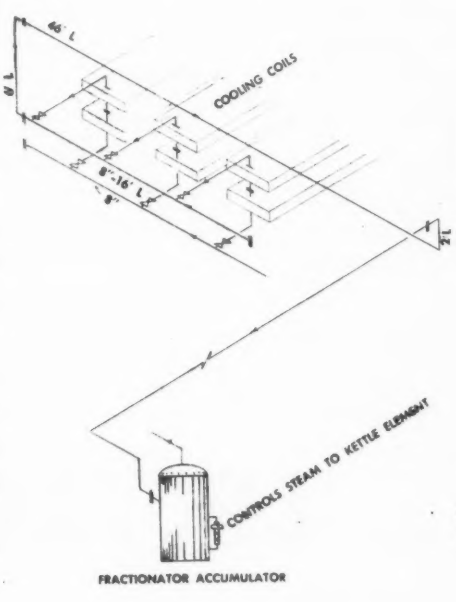
Purpose: To eliminate liquid build-up in coil headers to receive a more even flow of gas and liquid into accumulator.

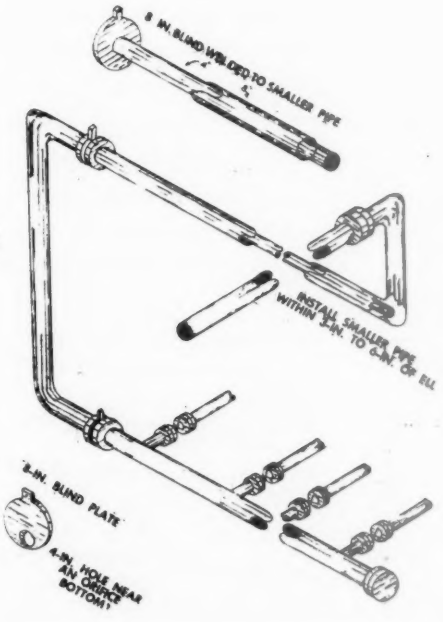
Description: Part I — A blind plate with an orifice cut in the lower section to increase line velocity whereby liquid is not allowed to build up.

Part II—A blind plate with a smaller size line pipe welded thereto with the smaller pipe extended to within a few inches of the vertical riser to a higher elevation on a pipe line.

The application of this kink eliminated the liquid trapping out in a deethanizer coil outlet header line to the overhead accumulator. Previous to this installation, the liquid collected in the header and carried over into the accumulator in slugs. The liquid level in the fractionator accumulator controls the steam to the kettle element. Any sudden variation of the accumulator level upsets the operation of the fractionator. After the liquid slugs were eliminated, the fractionator operation smoothed out. An additional 2 to 5000 gal of deethanized product were retained and a sharper cut was made in separating components.

‡NGAA—Class C, first prize, Permian Basin regional meeting.

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INSTALL SMALLER PIPE WITHIN 2 IN. TO 6 IN. OF BL
2-IN. BLIND PLATE
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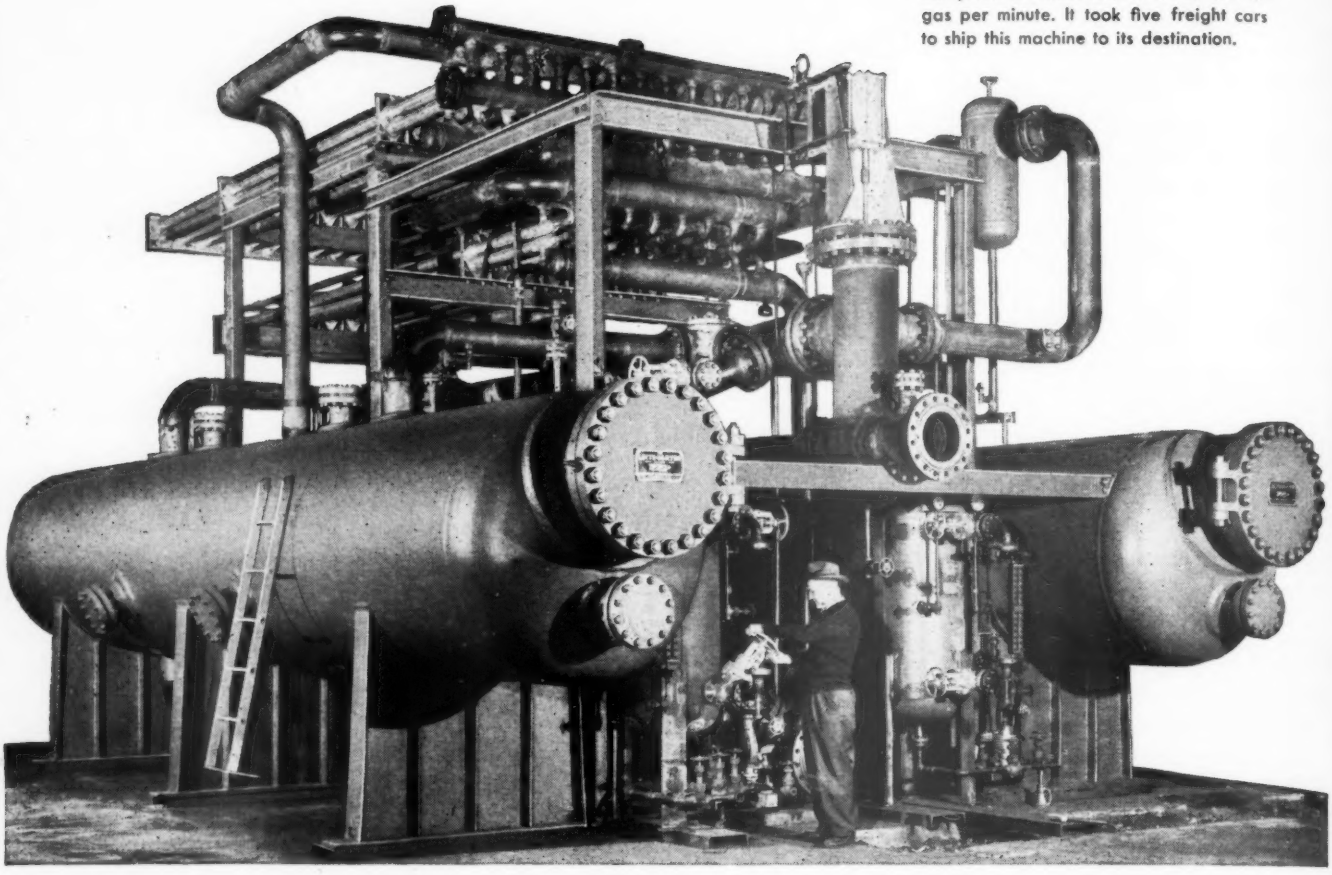

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Perhaps your need for DRYness is just as acute, but you require less volume... higher or lower pressure. There probably is a Lectrodryer already designed to fit your particular process. Lectrodryers will reduce dewpoints to as low as -100°F. They can lower humidity to a low 10%. Certain types will handle pressures up to 6000 psi.

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Petrochemicals—From Zero To Millions

Pressures and shortages of war made the impossible a fact — synthesis of rubber; stimulated powerfully other chemical syntheses

ARCH L. FOSTER†

IN THE minds of many acquainted with the development of the petrochemicals industry it "jes growed" like Topsy. Various non-related developments of an incidental nature occurred about or before the turn of the 20th century but little of any volume importance whatever took place before the early 1920's. Carbide and Carbon Chemicals Corporation then began operation of a process for the thermal decomposition (cracking) of ethane and propane to produce ethylene from which alcohols, glycols, polymers, and numberless other products are made. In so doing Carbide became the real pioneer in chemical manufacture from hydrocarbons of the petroleum-natural gas family.

In the early 1920's also Gomberg discovered the so-called chlorine-water reaction for making petrochemicals and intermediates of them. The reaction was characterized by Brooks* as "The most important single reaction in the whole field of the manufacture of chemicals from hydrocarbons." This reaction is used in the making of chlorohydrins and glycols.

In all history of the human race and the development of industry, many advances have been made as a result of either new conditions creating a new demand, or new processes making cheaply an old product formerly too expensive to be used in large quantities. After World War I, Brooks (*loc. cit.*) points out that the excess of nitrocellulose, available after the demand for explosives dropped to a few per cent of wartime needs, led to efforts to utilize this material thereby bringing out pyroxylin (nitrocellulose) lacquers. Developments in cracking hydrocarbons to make olefins, such as ethylene and proplyene, and the disordered condition of the German organic chemical industry caused the situation that a west coast engineer found in the '20's on a trip to the United States east coast. He reported the unbelievable sight of barrels and barrels of synthetic alcohols waiting on dock for shipment to Germany, formerly considered progenitor of organic chemicals!

Carbide and Carbon Chemicals Corporation and a few other companies continued, pre-World War II, to expand slowly. Carbide built a unit opposite Standard of Indiana's refinery at Whiting, Indiana, to convert ethylene and other olefins in waste still gases to organic chemicals. The olefin-bearing gases were piped from the refinery gathering system direct to the chemical plant across the fence. Monsanto, Dow, and others then became interested. Carbide and Carbon started selling ethylene oxide, major chemical intermediate made from ethylene, in 1929 at a price of $2.00 per lb in 100 gal lots. By 1939 Brooks reports this price down to 29 cents in tank cars; in in 1954 the price is about half that of 1939, showing the net result of both improved techniques of manufacture, and the lowered costs due to greater volume production.

The period following the early 1930's, and more especially the post-war period—1946 to date—saw the entry of a great number of aggressive companies, chemical and petroleum, into the general field, to make especially acids, aldehydes, glycols, alcohols, and myriad other oxygenated products, and numerous others as well. Carbide and Carbon built an ethylene oxide plant at Texas City, Texas, again drawing ethylene from gases from a local refinery (Pan American). This locale promised then to be and has since become one of the centers of petrochemical manufacture. Scores of plants are operating and building along the Texas-Louisiana Gulf Coast.

During the war the largest industry of what may be termed the petrochemical field grew up overnight, forced on a harried United States by the cutting off of natural rubber supplies from the East Indies by the Japanese invasion. Synthetic rubber of sorts had been made by German chemists during World War I for the same reason, stoppage of natural rubber by the enemy Allies. It is said that rubber was so far short of natural rubber in quality that Kaiser Wilhelm's state limousine rested on jacks in the imperial garage when not in use, to prevent the weight from putting a permanent flat in the tires.

American companies, Phillips Petroleum, Goodrich Tire and Rubber, and others had been working with rubber research for a time prior to the U. S. entry into World War II. Neoprene rubber had been made for some time, utilizing chloroprene, but had been used for non-tire purposes, articles for use where exposed to oils and greases, gasoline, and benzene, etc. The work and facilities of all these companies and of others that came into the problem, were pooled by the national government. Desperate, time-driven efforts were made to develop the now well-established processes for making butadiene, styrene and from them GR-S or tire-type rubber to make up the crucial shortage of rubber for the Allies; now fighting both Japan and Germany with Italy allied with them.

The saga of the development of our present types of synthetic rubber has no parallel in the annals of the human race. Backs to the wall, round-the-clock work became the universal rule in 1942-3 until the plants owned by the government got under way to meet the crisis and keep the armed forces rolling. Many were the "educated guesses" by harried technical leaders, taking long shots that the then rather embryonic processes would do the trick in making rubber from butadiene and styrene, a product first discovered by German chemists.

Two processes were developed for making butadiene, main ingredient of GRS type rubber; the alcohol process by Carbide and Carbon Chemical Corporation and the Standard of New Jersey butene dehydrogenation process. The alcohol was the more expensive process but availability of raw material (alcohol) and the process caused three plants to be built to use this method. The New Jersey butylene process was developed and installed in seven plants. Styrene synthesis was fairly well known, laboratory- and small production-wise, from benzene and ethylene. The latter was made from still gases or the cracking of ethane and propane, Ethylbenzene was made and the ethyl side chain dehydrogenated to the olefin. Synthetic rubber production for 1953 was about 780,000 tons, of which 625,000 tons was tire type (GR-S).

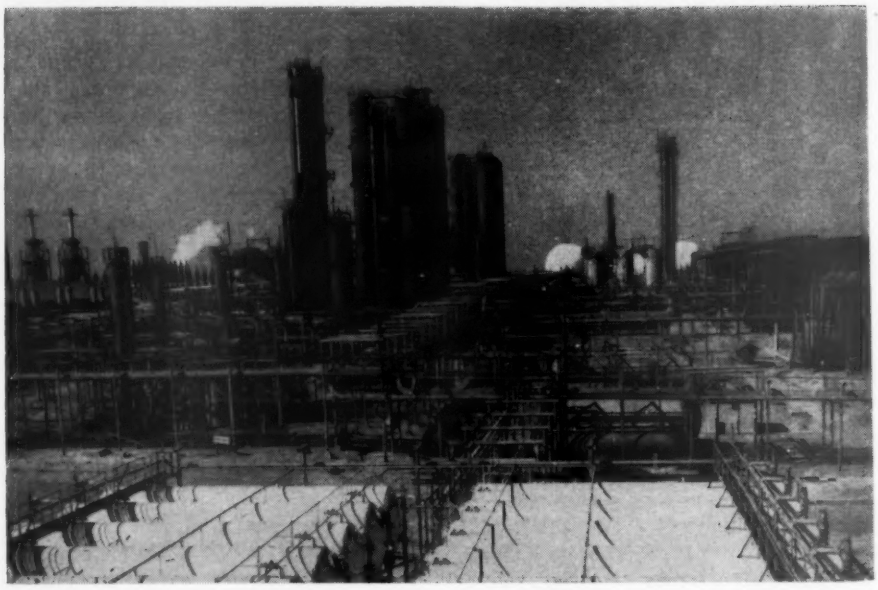
No Jules Verne could dream up a science-fiction story as completely amazing as the actual story of synthetic rubber. Japan lost the war, so did Germany, because they committed

†Editor, Refining and Petrochemical Edition.

*(The Petroleum Engineer, April 1954, page C-6).

EXCLUSIVE

XUM



Operating this butadiene unit and the rubber copolymer plant alongside, (Borger, Texas Panhandle), makes Phillips Chemical Company the only company producing synthetic rubber from the raw materials to the finished rubber.

that greatest of errors—underestimating the capacity of an adversary, in this case our capacity to make rubber and aviation fuel.

Another basic product from hydrocarbons, ammonia, has seen an almost phenomenal development, postwar. This process is based largely on the Haber synthesis, developed in Germany years ago and employed there, using coal tar and its byproducts for hydrogen, and nitrogen from the air. The present process uses partial combustion of natural gas to form carbon monoxide or dioxide, and hydrogen, minimizing water formation from atmospheric oxygen and hydrogen. The carbon oxides are extracted to leave a mixture of hydrogen and atmospheric nitrogen, which are reacted via a catalyst to form ammonia, NH_3. Urea, $H_2N\text{-}CO\text{-}NH_2$, is also made from ammonia and carbon monoxide, as an offshoot of this process.

More recently, hydrogen has been obtained for a few plants from the byproduct hydrogen from catalytic reforming of naphthas to produce motor and/or aviation fuel components or to make aromatics. In many plants large amounts of hydrogen are burned under stills, boilers, etc. In one or two plants hydrogen is being diverted to ammonia and other synthesis, as at Atlantic Refining Company's Philadelphia plant and reportedly elsewhere. This is a distinct saving both of natural or refinery gases and in process costs; the hydrogen is concentrated from the reformer gases and combined with atmospheric nitrogen in the typical process.

The quantities of synthetic ammonia produced in recent years has grown steadily and new methods have been devised for its application as fertilizer. In 1953 the estimate is 3,500,000 tons of ammonia as compared to about 1,000,000 tons in 1948. From January, 1953, to March, 1954, nine ammonia synthesis plants came on stream in the U. S., with a total capacity rating of more than 1600 tons per day. At least 20 plants are scheduled to start operations in 1954 and 1955, with estimated total capacity of nearly 3000 tons per day.

The number of other synthetic products developed in recent years is practically legion; a volume is required to report and evaluate these developments adequately. Aromatics are now made from petroleum and natural gas hydrocarbons in great quantities. Benzene from petroleum in 1953 was nearly 50,000,000 gal, as compared to about 220,000,000 gal from coal tar and coke ovens. Petroleum benzene production by 1955 is estimated to be 100,000,000 gal, a very substantial part of the 375,000,000 gal goal set by NPA for national preparedness in 1955. Toluene and xylenes production is also climbing; in 1952 petroleum yielded 64,000,000 gal of toluene and about the same quantity of xylenes. Para-xylene is now being extracted at least at 2 refineries as raw material for synthetic (Dacron) fiber synthesis.

The story of petrochemical developments can go on and on, like an Arabian Nights' Tale. One of the outstanding syntheses is that of glycerin, by Shell Chemical scientists. The processes based on the high temperature chlorination of propylene, carried out in such manner that the double bond in propylene remains intact while adding chlorine to replace hydrogen, then hydrating the product to glycerin, a three-carbon molecule, with a hydroxyl, -OH, group on each carbon, or to allyl alcohol with one hydroxyl group and the double bond intact. Substitution of hydrogen by chlorine uses two chlorine atoms for each hydrocarbon hydrogen replaced, the hydrogen joining one Cl atom to make hydrochloric acid. This reaction comes in handy at locations where the HCl can be used to make such products as ethyl chloride from ethylenes by addition, the ethyl chloride being used largely in making tetraethyllead, antiknock agent.

A great number of higher alcohols —propyl and i-propyl, primary, secondary and tertiary butyl, amyl, from which comes amyl acetate, "banana oil," an important solvent and chemical intermediate—are now made by hydrating the corresponding olefins, supplying innumerable raw materials for other syntheses without number.

The development of the synthetic detergents—syndets—is another saga of primary and growing importance, is treated by the Doctors Snell in another article in this issue and so will not be discussed here.

While for the time it appears that some petrochemicals are in overabundant supply, it is expected that this will prove merely that one phase of the chemical industry has moved ahead of the phases that consume these intermediates for other synthetic final products. It is only a matter of time until a balance is reached by the corresponding growth of petrochemical consumers' capacities. Synthetic resins and plastic compose a two-branched field of untold and unestimable limits.

As this is written, notice comes to hand that Carbide and Carbon Chemical Corporation is building a new unit to operate on the Oxo process to make little known and heretofore expensive and difficult to obtain alcohols such as iso-octyl, tridecyl, and decyl alcohols. Alcohols will be made by the simultaneous reaction of carbon monoxide, molecular hydrogen, and an olefin such as propylene, butylene, or ethylene, forming an aldehyde that is reduced by hydrogen addition to form the alcohol. Plasticizers are produced using these alcohols; tridecyl alcohol is used to make tridecyl mercaptan with hydrogen sulfide, which is used in turn in tire-type synthetic rubber manufacture.

Imagination cannot conceive of the rate and extent of advancement to come in petrochemicals in the next quarter century. However, good common sense and consideration of the advances made in the last 10-15 years gives a mind-picture that is nothing short of staggering to the scientist and the business executives of today.

* * *

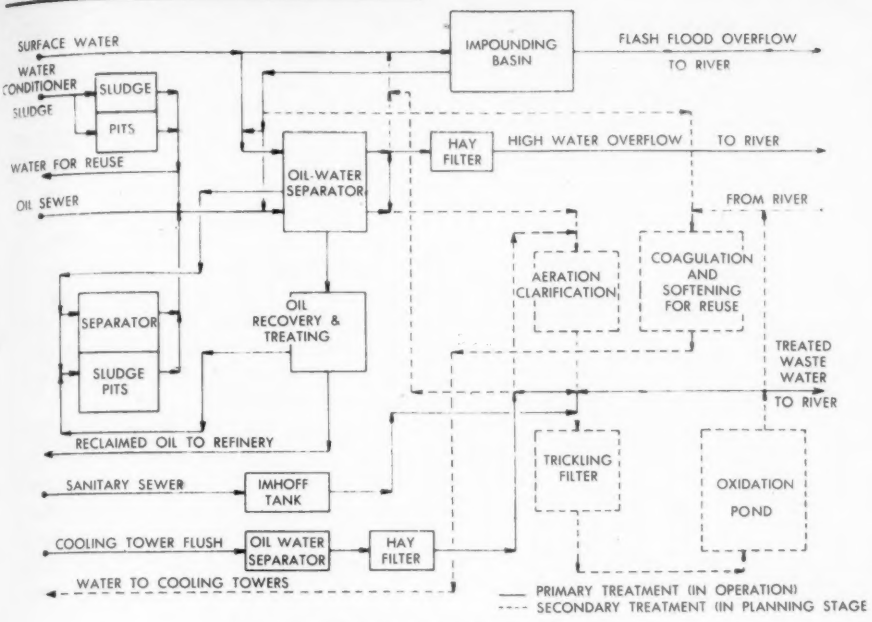


FIG. 1. Skelley's waste-disposal system.

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Part 2

Oil Reclamation And Waste-Disposal Facilities†

This article covers disposal of disposal cover waste oil and sludges; oil-water separator design; runoff impounding basin, and water-conditioning sludge.

W. L. PURSELL* and T. W. FERGUSON*

The new waste-disposal facilities being designed and installed at Skelly Oil Company's El Dorado, Kansas, refinery represent the latest standards established by the Kansas State Board of Health. Volume I of the API **Manual on Disposal of Refinery wastes: "Waste Water Containing Oil"** was the chief source of information for planning the installation, although the design had been in advanced stages before the new 5th edition was published.

A block flow diagram showing the extent of waste-handling and treating equipment generally required to produce a properly treated waste effluent is shown in Fig. 1. Solid lines outline the equipment recently put into operation at Skelly's plant.

These various pieces of equipment are required to remove oil and sludge from the waste effluent. The water which leaves these facilities is ready for further treatment in order to remove undesirable solutes and to reduce the biological oxygen demand (BOD). The Kansas State Board of Health classifies this recently installed equipment as primary treating equipment.

Waste-Treating Facilities

Facilities. Primary treating facilities for a refinery consist essentially of a gravity-type oil-water separator and all accessories necessary to make the separator work. These accessories also include facilities for handling oil, sludges, and emulsions removed from the waste during the operation of the separator.

Control of all storm runoff water must be sufficient to remove the waste oil from it. This water must be given further treatment in case it has become polluted with soluble substances. Need for controlling this storm runoff water was responsible for the design and construction of the impounding basin, as another accessory to the separator, as shown in Fig. 1. Use of this basin allowed a large reduction in the size of the oil-water separator.

When the water-runoff rate approaches the design capacity of the separator, the water will automatically start to flow into the basin. It may be pumped through the separator for oil removal after the storm is over.

Keeping emulsions, sediment, and sanitary sewage out of a gravity-type separator is a prerequisite for first-class separator operation. It is also essential to hold to a minimum the volume of waste to be treated. Fig. 1 shows the refinery wastes to be segregated into the following five streams so as to facilitate separator operation and other waste-handling processes:

1. Surface water, i.e., storm runoff.
2. Oil sewer: currently carries process water.
3. Sanitary sewer.
4. Water-conditioning sludges.
5. Cooling-tower flush.

The equipment necessary to segregate wastes, as listed, constitutes accessories necessary to make the oil-water separator perform. This equipment, and the impounding basin, the separator sludge-handling equipment, and waste-oil treating equipment, were all installed with the separator. These items and the separator constitute the primary waste-treating facilities discussed herein.

"Treatment-at-source" processes should be also be classed with the primary treating facilities. These processes are generally required to make the oil-water separator perform satisfactorily. Equipment such as ammonia-water strippers, spent-caustic and spent-acid treaters, mercaptan-disposal units, and special emulsion treaters, fall in this class. These processes are being installed as required, but are not described in this paper.

The hay filters shown in Fig. 1 constitute temporary installations. They have been suggested by the Kansas State Board of Health for a refinery only while it is operating primary waste-treating equipment, and a temporary permit has been granted to discharge partly treated wastes. These filters are not operated when the separator effluent is given further treatment before its disposal.

The data in the 5th edition of Volume 2 of the API *Manual on Disposal of Refinery Wastes* were applied for the design of the hay filters. These filters are composed of 3 baskets, each of which is 10 ft wide, 4 ft high, and 6½ in. deep. Horizontal filtration prevails. When suitably packed, each installation should filter satisfactorily 1675 gal per min of water, with an overall head loss of approximately 10 in.

Secondary Facilities. Refinery secondary waste-treating facilities handle only oil-free waste water. They consist of equipment designed to remove undesirable solutes and to reduce the biological oxygen demand. The scope of the secondary treating facilities now being planned for our refinery is shown by the dotted lines in Fig. 1.

*Presented during the 19th Mid-Year meeting of the American Petroleum Institute's Division of Refining, Houston, Texas, May 12, 1954.
†Skelly Oil Company, El Dorado, Kansas.

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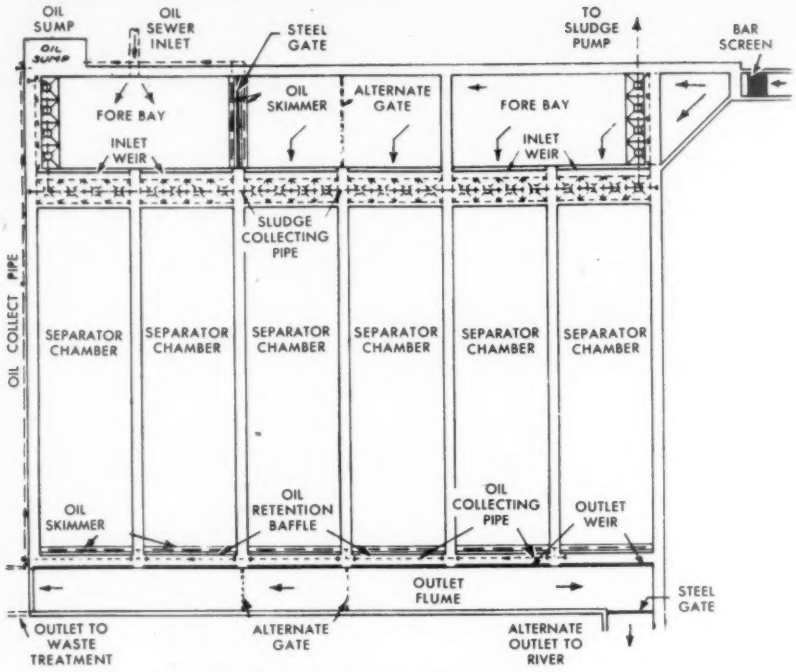

FIG. 2. Plan view of oil-water separator.

The trickling filter is being considered as the type of biological treatment for the reduction of oxygen demand. It was recommended by the Kansas State Board of Health after an extensive research program. It should give more uniformly satisfactory results than activated sludge, and should not require so much technical attention. These statements are supported by reports from municipalities in Kansas, and tend to be substantiated by current literature.

Fig. 1 illustrates a cold softener which treats water for re-use in the plant as part of the secondary waste-treating facilities. It is an important part of our waste-treating equipment because it will reduce cooling-tower flush rates by providing better-quality makeup water. This reduction will result in a smaller volume of waste to be treated. The softener actually becomes a part of secondary waste treating when waste-water effluent is charged to it.

Oil-Water Separator

Current refinery waste-water effluent amounts to about 1500 gal per min—not including sanitary sewage. This is the normal volume of water subject to oil removal and secondary treatment. A rainfall of about 2 in. per hour can increase this volume to about 101,000 gal per min, with about 3000 gal per min flowing in the oil sewer as process water.

Surface conditions inside the refinery are such that 100 per cent runoff was assumed when rainfall volumes were estimated. Allowances were made for the falling of the water inside fire walls around tanks, where it is retained and drained away after the storm is over. A gravity-type oil-water separator large enough to handle this 101,000 gal per min of water would have to consist of 40 single-stage chambers—each chamber 20 ft wide, 75 ft long, and containing 8 ft of water. The need for the storm-water impounding basin is apparent.

Space was found for the construction of an earthen basin with a capacity of approximately 17,000,000 gal. This amounts to more than all the runoff water from a 5-in. rainfall. The capacity of the oil-water separator was arbitrarily set at 15,000 gal per min so that the basin may be emptied in 24 hours by pumping through the separator at a rate which does not exceed separator rating. The normal waste water handled by the oil-water separator has the following inspections:

1. Temperature at separation, deg F. 80
2. Specific gravity at 80 F. 1.0010
3. Absolute viscosity at 80 F. poises 0.0092
4. Absolute viscosity at 100 F. poises 0.0074
5. Kinematic viscosity at 80 F, sq ft per sec 0.00000989
6. Specific gravity of oil at 80 F. 0.8762

Using these waste-water inspections, our 15,000-gal-per-min oil-water separator required 6 parallel single-stage chambers, each 20 ft wide, 72 ft long, and 7 ft deep, designed according to the 5th edition of Volume 1 of the API manual. Design methods in the 4th edition specified 6 single-stage chambers, each 20 ft wide, 69 ft long, and 6 ft 7 in. deep.

Fig. 2 shows the plan layout of our 15,000-gal-per-min oil-water separator. It may be operated as 2 separate units, i.e., 2 chambers on process water and 4 chambers on storm runoff, by the installation of steel gates in the separator fore bay and in the outlet flume, as shown in the illustration. This provides a means for isolating process water and taking it separately to secondary treating facilities. The entire separator operates as a single unit when these steel gates are removed.

The fore bay has been made 20 ft wide and equipped with oil-skimming and sludge-removal equipment identical to that used in the separator chambers. Major portions of oil and sludge are removed at this point. This feature has no influence on the design rating assigned to the separator.

Each pair of oil-skimmer pipes is drained by a single 6-in. pipe installed in the concrete wall between the 2 respective chambers. While still inside the concrete wall, these 6-in. pipes connect into a 10-in. collecting pipe located parallel to and below the skimmer pipes and behind the oil-retention baffle. The collecting pipe carries skimmed oil to the sump, where a float-operated pump transfers the oil to tanks located at the site. To allow for pipe cleaning, the collecting pipe has been installed with strategically located flanges.

Walkways, protected with handrails, are installed along both sides of the fore bay, along both sides of each chamber, and along the outlet end of the separator. The handrail around the outside of the separator is equipped with wire mesh to serve as a weed guard.

Four sludge-collecting hoppers are built into the bottom of the inlet end of each chamber and at the inlet and terminal ends of the fore bay. A single 4-in. sludge-collecting pipe carries sludge from the bottom of each hopper to the inlet of a pump which transfers the sludge to a pit. This sludge-collecting pipe is also equipped with special cleanout flanges.

For the purpose of keeping débris out of the separator, a bar screen was installed in the inlet flume just ahead of the fore bay. The bar screen is manually cleaned because some Kansas municipalities report more dependable results with manual cleaning than with mechanical cleaning. This bar screen was designed in accordance with the 5th edition of the API manual.

A side elevation of one separator chamber is shown in Fig. 3. This illustration shows the relative location of the oil-skimmer pipe, the oil-retention baffle, and the oil-collecting pipe. The

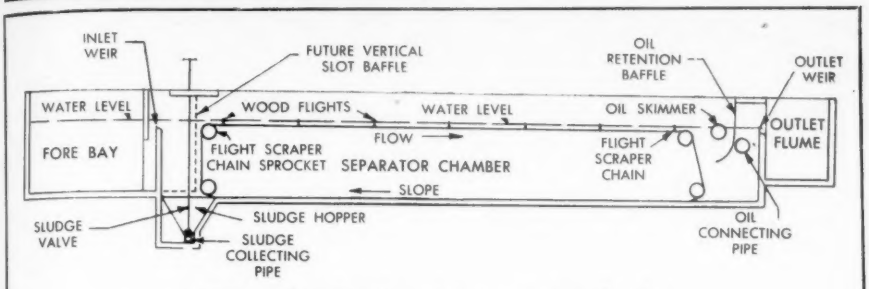

FIG. 3. Side elevation of one separator chamber.

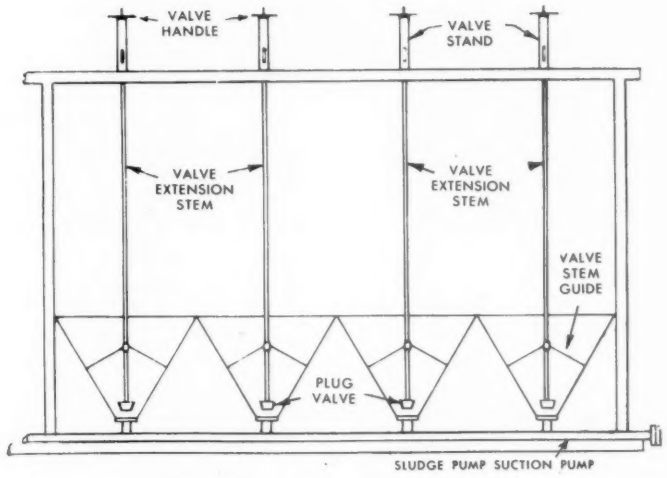

FIG. 4. End elevation of sludge hopper.

oil-retention baffle was extended to the top of the separator wall so as to retain control over oil during periods of extreme flood conditions. The outfall weir extends 1 ft below the highest known river flood stage. The top of the separator walls extend more than 2 ft above the highest flood stage.

The elevation of both the inlet and outfall weir is adjustable within a 3-in. range. Normal operation has the outfall weir set 3 in. higher than the inlet weir so that the inlet weir is covered with water at all times.

Water may be blocked from the individual chambers by lowering a wooden gate, 2 in. thick, into place on top of the inlet weir. The edge of the weir plate fits into a groove in the bottom of the wooden gate. The ends of the gate move through slotted guides built into the chamber walls.

All detailed design drawings covering the oil-water separator had been completed, bids had been received, and the contracts for construction were ready to be let at the time the 5th edition of the manual became available. It was possible to lengthen the chambers to agree with the new design methods, but it did not appear practical to hold up everything until the inlet baffle installation could be converted to the vertical-slot design.

The Kansas State Board of Health appeared more interested in complete submergence of the inlet baffle according to the present design than it was in the installation of the vertical-slot inlet baffle. On the other hand, our own experience with oil-water separators indicates that satisfactory operation may be had with the presently designed inlet weir 3 or 4 in. above the water level in the chamber. The present inlet weir design incorporates both sets of ideas. The relative merits of exposed and submerged inlet weirs are still to be established for our separator.

The Kansas State Board of Health has suggested that, for experiment, a slotted inlet baffle be installed in one chamber, as shown by the dotted lines in Fig. 3, so that the effectiveness of the slotted baffle may be compared with the present inlet baffle. This would reduce the effective length of the chamber to that provided by the design methods in the 4th edition of the manual, and the experiment would also test the new design methods. A temporary vertical-slot baffle is being designed for this condition. It will be installed if and when the need to improve the effectiveness of the separator is established.

The entire inlet baffle arrangement can be permanently replaced with vertical-slot baffles if the need justifies the cost. The authors feel, however, that a separator with adequate retention time, and with suitable width, depth, and length dimensions, can be given more effective assistance by a program of "waste treatment at source" than by the alteration of inlet and outlet design features. In other words, emulsions, sludges, and foul water should be kept out of the separator.

Fig. 4 shows an end elevation of one chamber at the sludge hoppers. It illustrates the design of the sludge-collection system.

The valves in the bottom of the hoppers are of our own make. Standard 6-in. gate-valve stems and hand wheels were used. A wheel stand, made from 3-in. pipe, has replaced the valve yoke. The valve seats were machined from 4-in. steel flanges, and the valve plugs were made from old pressure still-tube header plugs.

The valve stems are of 1-in. pipe. A small rod, welded to the stem, extends through a slot in the valve stand for the purpose of keeping the stem from turning when the valve is operated.

Sludge Pits

Waste water with sludge which is drained from water-softening processes flows through a gravity sewer into the water-conditioning sludge pits. There are 3 ft of approximately 1½-in. unwashed river gravel in the bottom of these pits. Water seeps through the gravel into a drain pipe. One drain pipe from each pit leads to a common sump. A float-operated pump transfers the water from the sump back to the plant, for re-use. A plan view of these water-conditioning sludge pits is shown in Fig. 5.

Each pit was made of such a size that it could hold sludge for 3 or 4 months with the water-conditioners operating at capacity. The measured density of damp sludge was used for this design. The resulting pit capacity proved to be more than adequate to meet present needs.

Fig. 6 shows the cross-section of the water-conditioning sludge-pit dyke at the sump. There is no system of water-collecting pipes under the gravel bed. The 6-in. drain pipe merely extends under the gravel about 6 ft, and enlarges to 8 in. in its inlet end. This 8-in. opening is covered with ¼-in. plate perforated with 1-in. holes on approximately 1½-in. centers. A bed of hand-picked larger stones was placed over this opening. The remaining gravel was dumped into the pit, and was leveled with a bulldozer. One of these drain pipes will carry approximately 50 gal per min of clarified water into the sump.

Each drain pipe is equipped with a connection for bumping the gravel bed with air should sludge in the gravel block the flow of water. Air bumping has been used before.

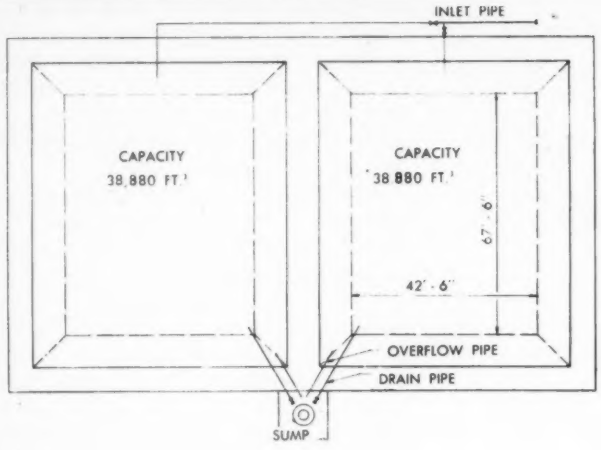

FIG. 5. A plan for water-conditioning sludge pits.

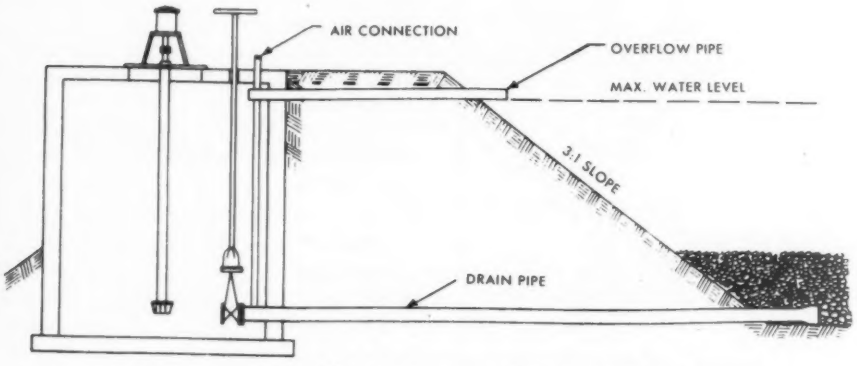

FIG. 6. A Cross-section of a water-conditioning dyke and sump.

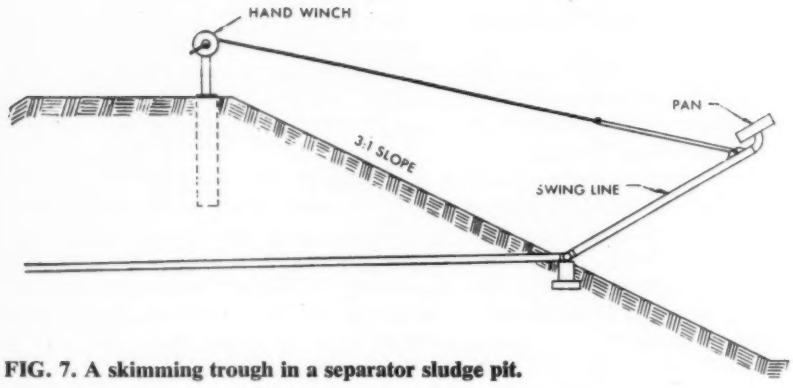

FIG. 7. A skimming trough in a separator sludge pit.

In addition to the drain pipe, each pit is equipped with an overflow pipe which leads to the sump. This overflow pipe will allow the pit to continue in operation with the drain pipe blocked off. In such an event, sedimentation must be relied upon to provide a clarified pit effluent.

Inside pit walls were constructed with approximately a 3:1 slope so that heavy crawler equipment may be used for sludge removal and pit repair. It is anticipated, however, that sludge removal with a clam shell will be the regular cleaning procedure.

Boiler blowdown sludge may not be handled by these pits if the recovered water is to be used for generating steam. Recycling the blowdown water will increase total dissolved solids in the boiler feed; therefore, the blowdown rates must be increased. No saving in water results.

Chemical analysis and field testing have proved our water-conditioning sludge to be a satisfactory source for agricultural fertilizer. Besides calcium carbonate, a major constitutent is tricalcium phosphate. The sludge not only replaces limestone normally used on acid soils, but supplies a slow-acting phosphate welcomed by farmers. Normal commercial phosphate fertilizers are quite soluble, and leach away in a year or so. Our remaining problem is to get the sludge in a dry, granulated form suitable for use in lime spreaders.

Separator sludge pits are built with the same 3:1 slope for inside walls. They have no gravel in the bottom and no water-collecting sump. Each pit is equipped with an adjustable skimming trough, as shown in Fig. 7. Water and oil which collect above the sludge may be drained or pumped back through the oil-water separator.

Sludge from our old oil-water separator created quite a disposal problem because of the relatively large amount of oil it retained. Some means of sludge disposal, other than lagooning, may be required if the sludge from the new facilities continues to have these same properties.

Cooling-Tower Flush

The oil-water separator which handles cooling-tower flush water (Fig. 1) was built as part of a fire pump station, and it is located in the refinery, where it becomes part of the fire protection water supply system.

Flush water from the cooling towers is collected in a single gravity drain pipe, from which it flows into a retention basin which also serves as an oil-water separator. Two pumps take water from this basin and discharge it into regular water mains of the fire-protection system. The basin may also receive makeup water from the regular water-supply system.

Original basin design called for a 2-hour water supply for both pumps, with no water running into the basin. This gave 1-hour retention time for cooling-tower flush at the maximum purge conditions in contrast to about 30-min retention time in our main separator. Final detailed design for a two-chamber separator was determined by applying API separator-design principles to the cooling-tower flush water, except that the chambers were arbitrarily made longer to provide desired retention time on behalf of the fire-protection water pumps.

Each chamber is equipped with a separate inlet, outlet and pump suction line so that one chamber at a time may be taken down for cleaning and repairs.

The dianodic chromate-phosphate treating method is used on cooling water to inhibit corrosion. Because they are toxic to marine life, chromates must be removed from the cooling-tower flush before the latter's disposal. This is about the extent of secondary treatment required for our cooling-water purge so long as no oil is present.

Layout of Equipment

Fig. 8 shows the overall layout and simplified flow diagram of the primary waste-treating equipment which was installed as an independently operating unit.

Each tank shown in Fig. 8 is

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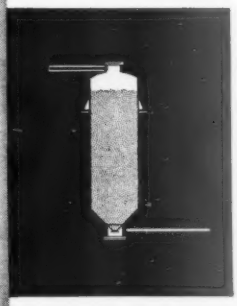

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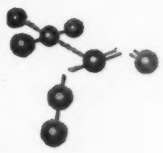

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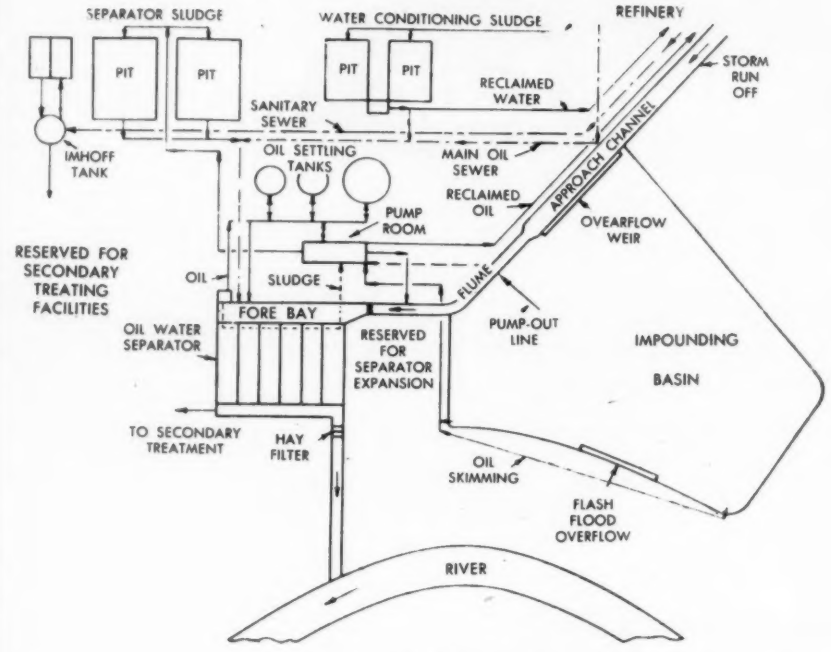
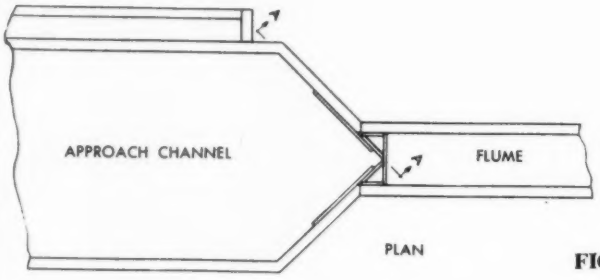


FIG. 8. Overall layout for a primary waste-treating system.



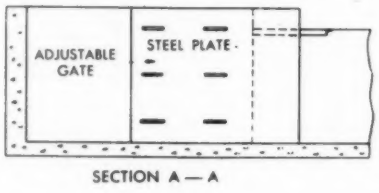


FIG. 9. Adjustable gate outlet end of an approach channel.

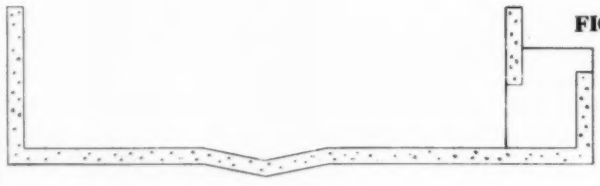


FIG. 10. Cross-section—Approach Channel of Side Overflow Weir.

equipped with a steam coil located about 3 ft from the bottom so as to allow room for sludge accumulation. Each tank also has an automatic water-drawoff valve, internal swing pipe, and a cleanout door sheet.

The two small tanks operate in parallel to receive all oil, water, and emulsion skimmed from the separator. The top layer of clean oil is transferred from these two tanks directly to the plant, for rerunning. Water is drained from the bottom of the tanks back into the separator. Emulsions are transferred from small tanks to the large.

Whenever practicable, clean oil is recovered from the large tank. As the emulsion increases, the oil is transferred into the refinery for further treatment, for subsequent emulsion breaking, and for ultimate disposal.

The currently used batchwise emulsion-breaking process, which utilizes heat and demulsifying agents, gives acceptable results, but leaves much to be desired. It adds alkalinity to our currently alkaline waste effluent. It produces a waste water and a sludge which are difficult to prepare for final disposal. We are considering the merits of a process which utilizes a filter to break emulsions in an effort to avoid these sludge and water-disposal problems.

The Impounding Basin

Fig. 8 shows the location of the impounding basin with respect to the oil-water separator, as well as the relative location of other primary waste-treating facilities which have been installed. A simplified flow diagram also shows the relation of the various facilities.

The refinery has no regular storm sewer. Open ditches are utilized to carry storm runoff water into the concrete approach channel. A concrete flume carries the water from the approach channel to the fore bay.

Inability to keep oil and process water out of these storm ditches made it necessary to install waste-treating facilities capable of handling volumes much larger than our normal effluent. If a large oil spill were to run down one of these open ditches, a definite hazard would result, particularly if this occurred while the ditch was flowing over. An adequate storm sewer system would alleviate these problems.

Fig. 9 shows the details of adjustable gates installed at the outlet end of the approach channel for the purpose of controlling the flow of water into the inlet flume. Gates adjust horizontally so that floating oil may continue on to the separator at all times.

The approach channel is equipped with an oil-retention baffle and overflow weir along the side next to the impounding basin. Fig. 10 shows the cross-section of the approach channel at the side overflow weir.

The adjustable gates (Fig. 9) are set so that channel flow must approach 8000 gal per min before the level in the channel will force water out the side into the impounding basin. When the channel level is high enough to force 12,000 gal per min through the adjustable gates into the separator, 237,500 gal per min will be going over the side overflow weir into the impounding basin. The water going into the impounding basin will come from the bottom of the approach channel. Any floating oil should continue on to the separator. Satisfactory control over the oil during a rainfall of 5 in. per

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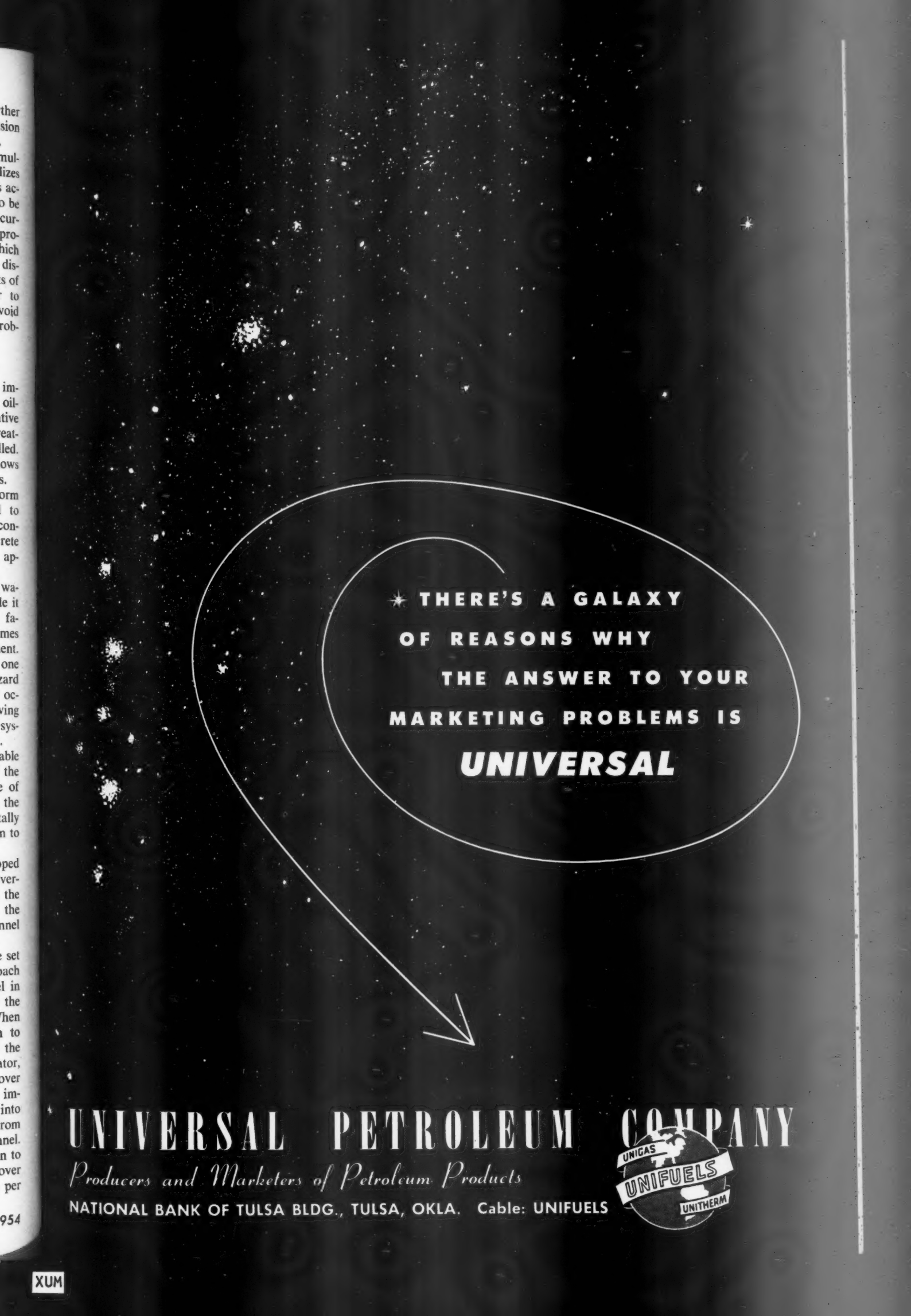
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hour should be maintained.

Oil may be removed from the water in the basin by pumping the water through the separator at a maximum rate of about 10,000 gal per min, and the remaining separator capacity will take care of current waste water from the refinery. If the impounded water must have secondary treatment, the pumping rate from the basin will be limited by the capacity of secondary treating equipment.

With secondary treating equipment capable of handling 5000 gal per min of water, use of the impounding basin will allow both primary and secondary treatment for all water from a 2-in. daily rainfall. Complete treatment may also be provided for water from a rainfall of 2 in. per hour for a period of 2 hours. If runoff water requires oil removal only, water from rainfall may be handled at twice the foregoing rates. The problem will be one of getting the basin emptied back through the separator in time for the next rain.

When rainfall rates exceed those given, it will be necessary for some of the water to pass on out of the basin directly to the river. The basin's capacity, however, permits a longer retention period for water from a rainfall of 10 in. per hour than is provided by the oil-water separator when the latter operates at rated capacity. Thus the basin should provide satisfactory control over waste oil, even during rains of cloud-burst proportions.

Oil may be expected to collect on the water in the impounding basin in spite of precautions taken in the design of the approach channel. The major portion of this oil will be removed as the basin is pumped empty. The impounding basin has been equipped, however, with two oil-skimming troughs similar to those installed in the separator sludge pits. The troughs are located in corners of the basin where prevailing winds cause floating oil to accumulate.

The design of this waste-handling equipment had been approved by the Kansas State Board of Health before construction started. Inasmuch as the impounding basin and the separator were to be located on ground which is submerged during highest river flood stages, it was also necessary to have the construction approved by the Kansas Board of Water Resources.

The walls of the basin and separator were to be built high enough to keep river water out. The approval by the water-resources board requested that the basin and separator walls be located 275 ft from the river channel so they would not block river flow at flood stage and cause greater flood damage upstream. Also this located the walls in such a way that they could become part of any future flood-control levee program without their having to be moved.

Pump Room

The pump room in Fig. 8 houses two basin pumps, as well as a centrifugal sludge pump and two swinging-vane rotary pumps for skimming and oil transfer. The swinging-vane pumps may be used to pump skimmed oil from the sump when the regular sump pump is down for repair.

The pump room is excavated so that the floor level is approximately the same as the sludge-collecting pipe and the impounding basin floor. This facilitates handling of sludge and emptying the basin. The room is equipped with a traveling overhead crane to assist pump and motor repair. An unexcavated end of the building is partitioned into an operating office and an oil and tool room.

Each of the basin pumps has a rating of 5000 gal per min. One pump will be able to empty the basin at a suitable rate most of the time. A pump breakdown will not take the entire pump capacity out of service as would be the case if only one 10,000-gal-per-min pump had been purchased.

The inlet end of the suction pipe to the basin pumps is equipped with a swing joint and cable. The end of the pipe may be raised from the water for the purpose of cleaning the intake screen and for working on suction valves inside the pump room.

A round Imhoff tank provides primary treatment of sanitary sewage. The effluent from this tank may be given effective secondary treatment by putting it through a biological filter. In fact, it is almost necessary to be able to seed the biological filter with sanitary sewage before the filter will satisfactorily treat the normal refinery waste water. Septic-tank effluent is not satisfactory for this purpose.

The completion of the primary waste-treating facilities described herein brings our waste-disposal construction to the halfway mark. The design and construction of the planned secondary treating facilities constitute a job of about the same magnitude as the one just finished. * * *

SUMMARY

1. Primary waste-treating facilities for a refinery are those facilities necessary to remove oil and sludge from the waste water.

2. Secondary waste-treating facilities are those necessary to remove undesirable solutes and to reduce chemical and biological oxygen demand of the waste water.

3. The trickling filter is being considered as the more practical method of biological treatment for refinery wastes.

4. Design methods contained in the 5th edition of Volume I, API *Manual on Disposal of Refinery Wastes*, gave an 11 per cent larger separator than the methods in the 4th edition, based on our waste-water properties.

5. A design for the separator fore bay and an arrangement for preliminary oil and sludge removal are presented as alternates to those given in the 5th edition of the manual.

6. The design of an oil-water separator capable of operating as two independent, parallel units is presented.

7. A simple gravel bed of suitable thickness is the only underdrain system required for satisfactory removal of water from water-conditioning sludge pits.

8. Our water-conditioning sludge gives satisfactory results when it is used as an agricultural fertilizer.

9. The oil-water separator normally required for proper handling of cooling-tower flush water may also be utilized to impound water for use in fire fighting.

10. The use of a water-impounding basin will allow an 85 per cent reduction in the size of the oil-water separator without loss of control over the waste oil in the storm runoff water.

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Chemical Flocculation Of Refinery Waste†

ROY F. WESTON* and R. G. MERMAN*

THE Atlantic Refining Company recently (December, 1953) started operation of a nominal 10 mgd** chemical flocculation waste treatment plant. This plant was constructed to treat oily waste waters from the north yard of the Company's Philadelphia refinery. The plant is a part of a pollution control plan inaugurated to comply with the requirements of the Clean Streams Program of the Pennsylvania Sanitary Water Board.

Prior to selecting chemical flocculation treatment for the yard effluent, comprehensive waste water surveys and pilot plant investigations were undertaken. The industrial waste survey was conducted in accordance with principles previously reported.[1] Quantitative data were obtained on the flow and the mineral and sanitary quality of all waste water streams discharging to the Schuylkill River. At the same time, quantitative data were obtained on the river itself. From the plant effluent survey, the pollution effects on the Schuylkill River and the Standards of the Pennsylvania Sanitary Water Board, it was possible to define the pollution abatement problem as follows:

1. Reducing effluent oil contents below a maximum permissible value of 30 ppm.

2. Reducing organic (biochemical oxygen demand) pollution so that the dissolved oxygen content in the Schuylkill River will not be depleted below a minimum value of 50 per cent saturation.

3. Controlling the effluent pH to a minimum value of 6.0.

In-plant surveys were made in 1947 to determine the sources of the various wastes contributing to the pollution abatement problem. Quantitative flow and quality data were obtained by studying area sewers and individual manufacturing units. The data obtained made it possible to evaluate various abatement procedures. Prior to evaluating possible solutions to the problem, a policy decision was made that "proposed abatement procedures must provide minimum possible interference with manufacturing operations."

Investigations revealed that local treatment facilities were impractical in most cases because of space limitations, high installation and operation costs, and poor operation control. It was also determined that local treatment would not preclude the necessity of effluent treatment. Therefore, library and laboratory research studies were inaugurated to determine possible effluent treatment methods.

As a result of these preliminary investigations, it was decided that pilot plant studies should be made of: (1) oil separation, (2) chemical flocculation and (3) biological filtration. Oil separation studies were made using duplicate separators and aeration facilities. The results of these studies have been reported elsewhere.[2] It was found that no advantage resulted from 0.25 to 1 hours aeration before or after separation. The biological filter studies indicated that petroleum refinery wastes could be treated by biological processes but that the character and variability of waste water quality from the area under consideration would present serious operating problems.

The chemical flocculation pilot plant facilities were installed so that three different treatment variables could be studied simultaneously. Two identical conventional flocculation, sedimentation units were constructed and a third was supplied by an equipment vendor. The design capacity of the twin pilot plant units was 10 gpm each. The vendor's unit also had a nominal capacity of 10 gpm. These units were operated for approximately 6 months. The results of the pilot plant observations have been reported in the proceedings of the Fourth Industrial Waste Conference, Purdue University, 1948.[3]

The full scale plant to be described below was designed on the basis of the findings of the pilot plant studies.

The waste waters of the 208-acre north yard of the Philadelphia refinery drained to the Schuylkill River through 7 different combined process-surface drainage sewer outlets. Process waste waters originate from manufacturing processes for the desalting, distillation, thermal and catalytic cracking, polymerization, alkylation and blending of motor fuel stocks; the distillation and selective solvent refining of lubricating oils; the preparation of white oils; the deoiling of waxes; the processing of asphalts; the production of synthetic detergents; the manufacture of sulfuric acid and treatment of slop oils.

In addition, wastes originate from boiler houses, boiler feed water treat-

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*The Atlantic Refining Company.
**10 mgd = 10,000 gal per day.

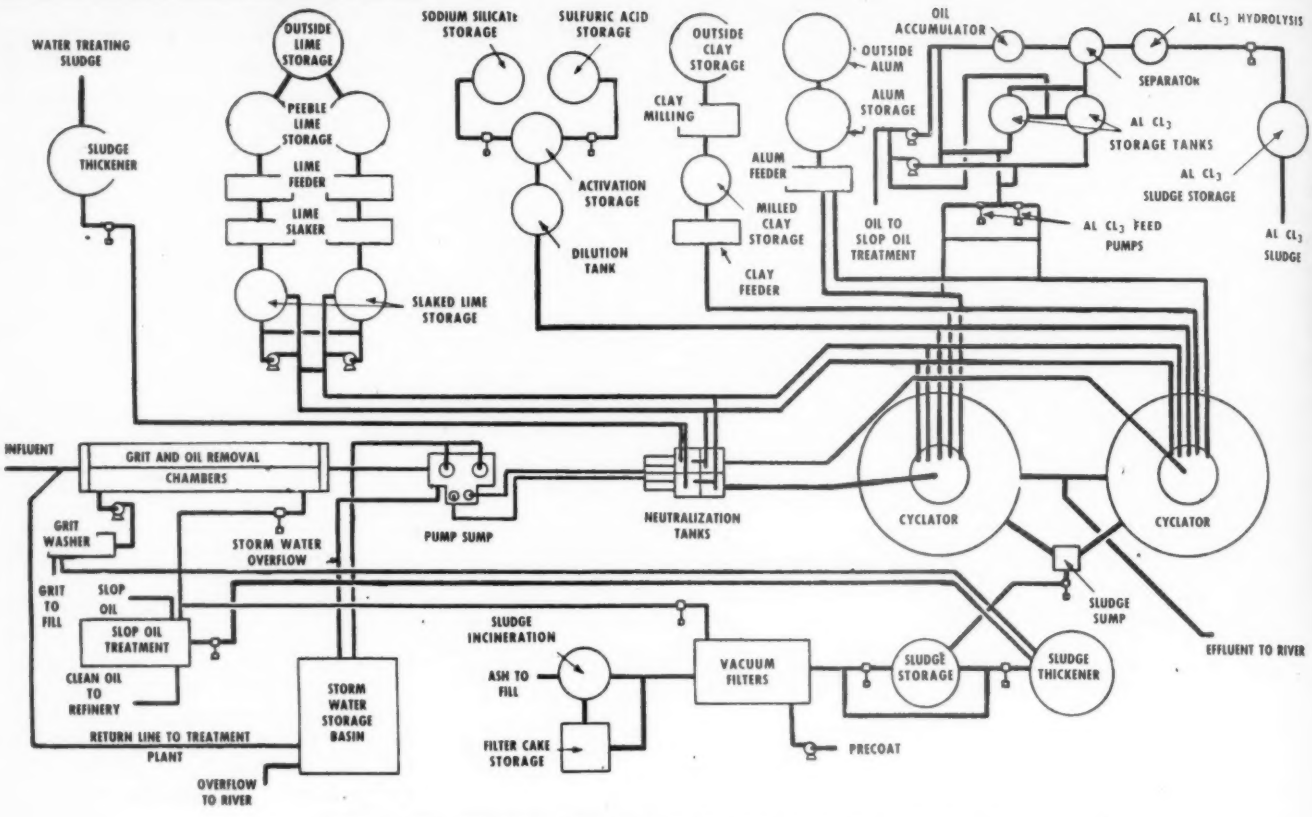


FIG. 1. Simplified flow diagram of Atlantic's waste disposal system.

ment plants, pump houses, gas compressor houses, tankage facilities, mechanical shops, storerooms, warehouses, garages, locker rooms, and field offices. The various manufacturing and associated activities produce waste waters containing free and emulsified oil, waxes, alkaline waters, acid wastes, condensate waters, sludges, solids, waste caustics, special chemicals, and both septic tank treated and untreated domestic sewage.

The lack of space for adequate treatment or control facilities at the different sewer outfall locations and problems associated with the operation of dispersed treatment units made it advisable to construct an intercepting sewer system to collect and convey the various waste water discharges to a common treatment site.

An investigation of a comparison of overall water supply, sewerage and waste treatment costs with cooling tower installation and operation costs demonstrated the economic advisability of reducing waste water flow by installing cooling towers. Cooling towers were installed at all units using cooling water quantities of 1 mgd or more. Where possible, uncontaminated cooling waters were diverted directly to the river.

By the use of cooling towers and flow diversions, it was possible to reduce the waste water flow from 30 to 8 mgd. Management determined that

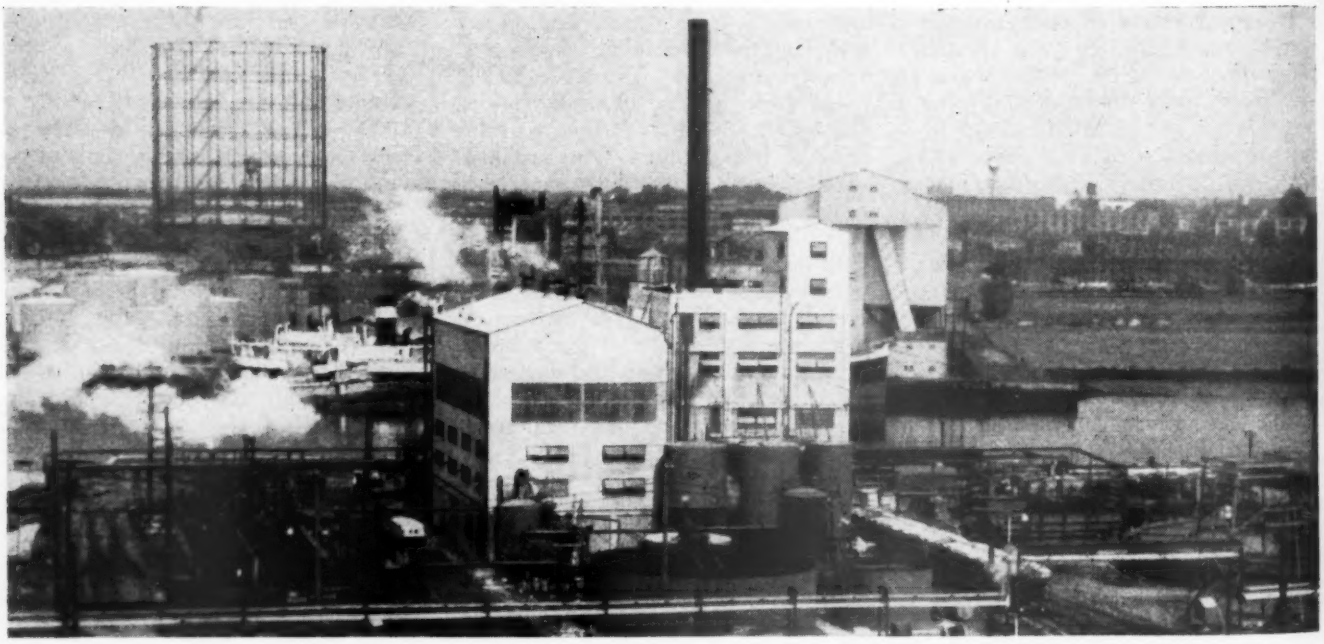


FIG. 3. Panoramic view of waste treatment plant in Atlantic's 'North Yard'.

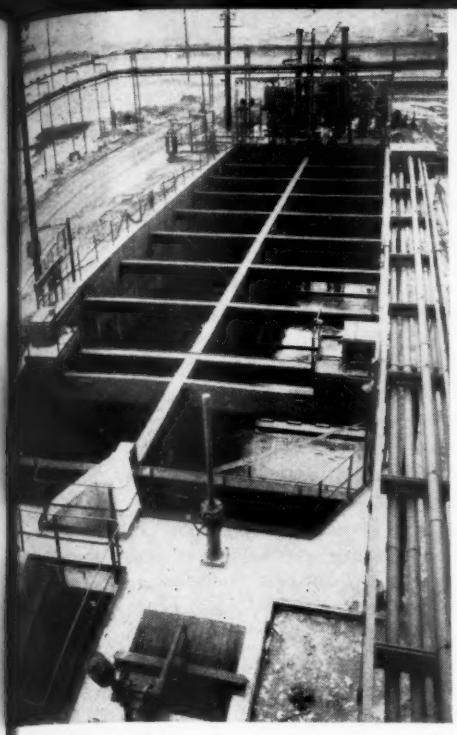


FIG. 4. Oil separators and auxiliary equipment.

a 20 per cent expansion factor should be used in determining the design capacity of waste treatment facilities. Therefore, the chemical flocculation plant was designed for a dry-weather flow thruput capacity of 9.6 mgd.

The plant sewerage system is of the combined type; i.e., both process and surface drainage are carried in a single system. At times of storms, considerable runoff from rainfall drains into the sewerage system. Under these conditions, the rate of flow from the plant may increase up to 10 to 20 times dry weather flow rates. It was possible to estimate flow rates for various design storm conditions by developing a unit hydrograph from known rainfall and gaged runoff data. Once a year the runoff rate may be as high as 58 mgd (1 year storm). Once in 10 years the rate may be as high as 144 mgd (10 year storm). A 50-year storm would produce runoff rates as high as 217 mgd. Local conditions made it necessary to use all three rates in design considerations.

The existing oil separation and collection facilities were antiquated. Therefore, it was decided to install new oil separators as a part of a the complete chemical flocculation plant. A simplified flow diagram of the plant is shown in Fig. 1.

General Description

The basic treatment operations include: (1) oil separation, (2) neutralization (3) chemical flocculation, (4) sludge dewatering, and (5) sludge incineration. The waste water passes through an oil separator to neutralization and chemical flocculation facilities and thence to the Schuylkill River (Fig. 3). Separated oil is pumped to slop oil treating facilities and settled suspended solids (i.e. sludge) are thickened, dewatered, and then incinerated. The ash is deposited as fill.

Waste water enters the plant via a 7 ft massey duct reinforced concrete sewer. At the entrance to the grit and oil separator (Fig 4), the water passes through 1-in. opening bar screens to remove large debris. In the separator, oil is collected at the surface and settleable material (sludge) is collected at the bottom. Chain type collection mechanism moves oil to the outlet end of the separator and sludge to the inlet end. Accumulated oil is skimmed into a float controlled trough from which it is continuously pumped to slop oil treating facilities. Sludge is scraped into a hopper from which it is pumped intermittently to a grit washer (Fig 5).

The grit washer is a hydraulic classifier that separates cinders, sand, and gravel (i.e. grit) from the sludge. The grit is dewatered and washed by an inclined screw as it is elevated above the water level in the unit. The dewatered material is dropped into a skid for use as fill. The fines overflow the grit washer into the auxiliary thickener.

The separated waste water flows under the oil skimmer and through a sutro weir into a pump sump. Dry weather flow and storm water flow up to 19.2 mgd is pumped to the inlet compartment of the neutralization tanks. Flows in excess of 19.2 mgd are pumped to a storm water basin which has storage capacity for a 1 year storm. Flow in excess of a 1 year storm flows under a baffle, over a broad crested weir and out of the basin into the Schuylkill River. Accumulated water is returned to the inlet end of the separator for oil and grit separation and thence to the pump sump for discharge to the chemical treating section of the plant.

The waste water flows from an inlet

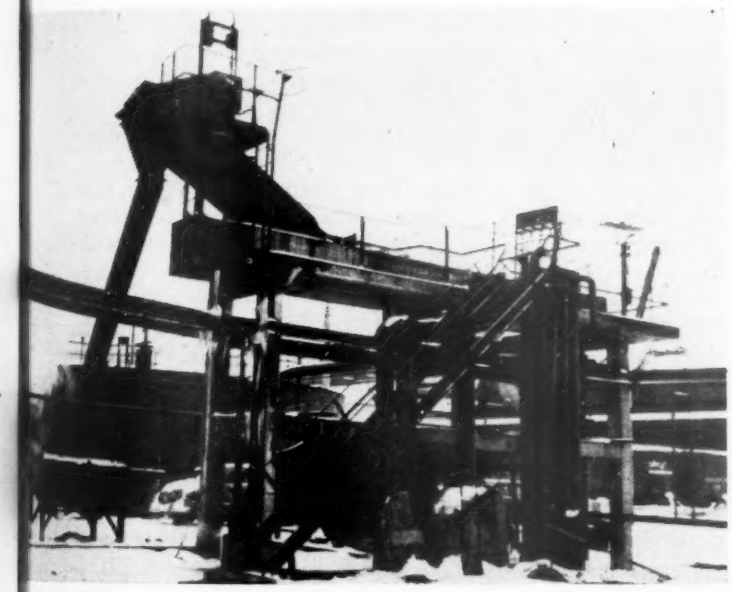


FIG. 5. A grit-washing unit at the Point Breeze refinery.

FIG. 6. "Cyclator" units, the position and function of which is indicated in Figs. 1 and 2.

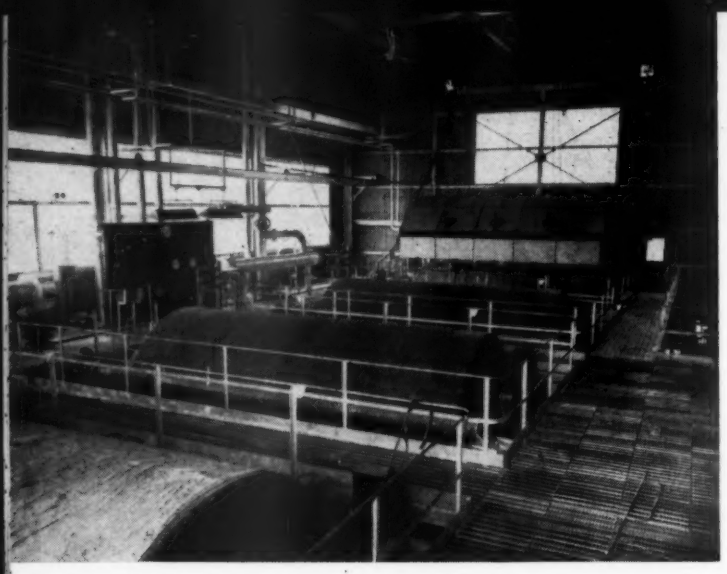


FIG. 7. Vacuum Precoat filters for removal of solid and filterable wastes.

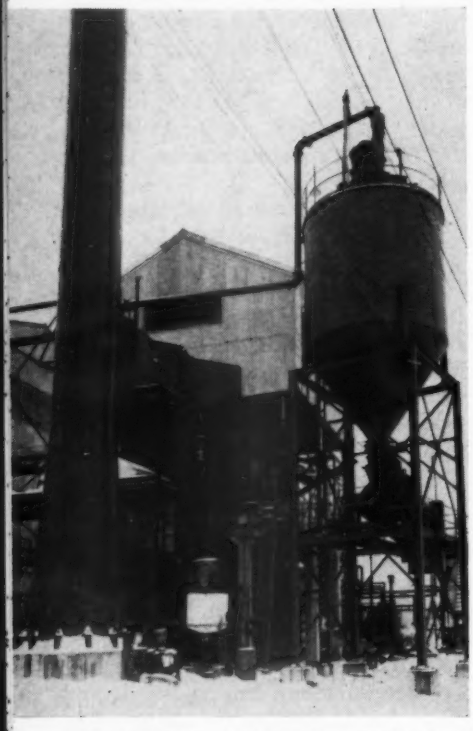


FIG. 8. Sludge incinerator-waste heat boiler combination for recovery of profitable heat from wastes.

compartment over rectangular, sharp crested, contracted weirs into two neutralization tanks in series. Each neutralization tank is equipped with a turbine type mixer and piping for the addition of slaked lime slurry and boiler feed water treatment sludge. The wastes are neutralized by adding these materials under automatic pH control. The neutralized waste flows to chemical flocculation tanks known as cyclators (Fig. 6). Here it is mixed with coagulants, coagulant aids, and recycled flocculation suspended solids.

Aluminum chloride and alum may be added as coagulants and activated silica, clay, and lime slurry may be added as coagulant aids. The floc formed by the coagulants and coagulant aids together with the recirculated preformed floc enmesh suspended oils and solids and clarify the waste. As the floc settles from the treated waste water, it carries the contaminants with it to the bottom of the cyclator as sludge. The treated waste water overflows the cyclators through orifices and drains to a clarified effluent sump and thence to the Schuylkill River.

The sludge is concentrated and scraped to drawoff sumps in the cyclators from which it is drained intermittently under automatic control to a sludge sump. Sludge is pumped from the sump to a storage tank under liquid level control. From the storage tank, sludge is pumped to rotary vacuum precoat filters (Fig. 7). Automatic controls adjust the flow to the filters equal to the filtration rate. Water is drained from the sludge solids to the inside of the filter drum. This filtrate drains by gravity to a filtrate receiver from which it is pumped to the plant sewers. The relatively dry cake and a thin layer of precoat is cut from the surface of the filter and discharged onto a continuous belt conveyor. The conveyor carries the filter cake to a single rotating hearth incinerator (Fig. 8), where the oil and other organic matter is burned from the sludge. Sufficient oil is normally present so that heat will be produced in excess of that required to sustain combustion. A combustible free ash is pneumatically conveyed to an ash storage hopper from which it is dumped to trucks for disposal as fill.

Miscellaneous sludges and bottoms are collected in a tank known as an auxiliary thickener. Materials accumulated in this tank are dewatered or deoiled on the vacuum precoat filters. One filter is equipped so that it can be used for slop oil filtration.

The plant has been designed for sustaining operation 100 per cent of the time and for providing maximum flexibility of operation. All major units have been provided in duplicate, each of one half design capacity. Where duplication was impractical, provisions have been made for sustaining operations by storage facilities for process materials, bypass arrangements, or inventories of spare parts. A plot plan of the plant is shown in Fig. 2.

Detailed Description

Grit and Oil Separator. The separator is designed to provide grit removal for all flows up to a 10 year storm and 94 per cent removal of separable oil at 9.6 mgd (Fig. 4). It consists of two parallel reinforced concrete channels, each 110 ft long, 16 ft wide and 4.5 ft minimum water depth. Flow enters the unit through Everdur bar screens having 1-in. openings. Effluent from each channel passes under a skimming trough and effluent baffle and through sutro weirs into the main pump sump.

The sutro weirs are constructed of Everdur and serve to control velocities in the unit at or below 1 ft per second for all storm flows. Velocities of this magnitude are required for satisfactory grit removal. Grit is moved to hoppers at the inlet end of each channel by flight scrapers which return at the water surface, moving oil toward the skimmer at the outlet end. Grit is pumped from each of 4 hoppers to a grit washer by a 350 gpm centrifugal Morris Trash pump or its identical spare. These pumps are located in a pit adjacent to the hoppers and have open impellers constructed of flint metal. All piping is high silicon cast iron. Two water jets are provided in each hopper to loosen grit prior to pumping.

Separated oil is removed in a pneumatically operated combination skimmer and oil baffle which is automatically positioned in reference to the water level in the separator. Construction is of stainless steel to resist corrosion. Skimmings are lifted from the skimmer troughs by means of three 80 gpm

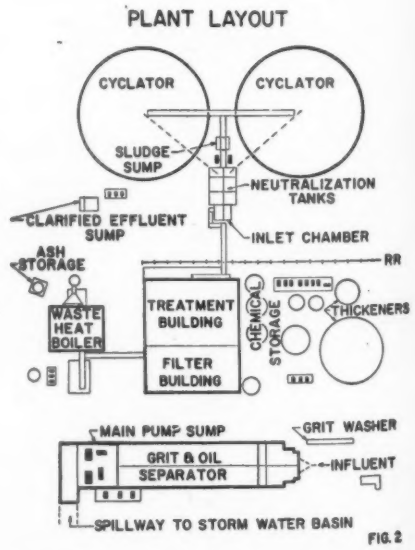
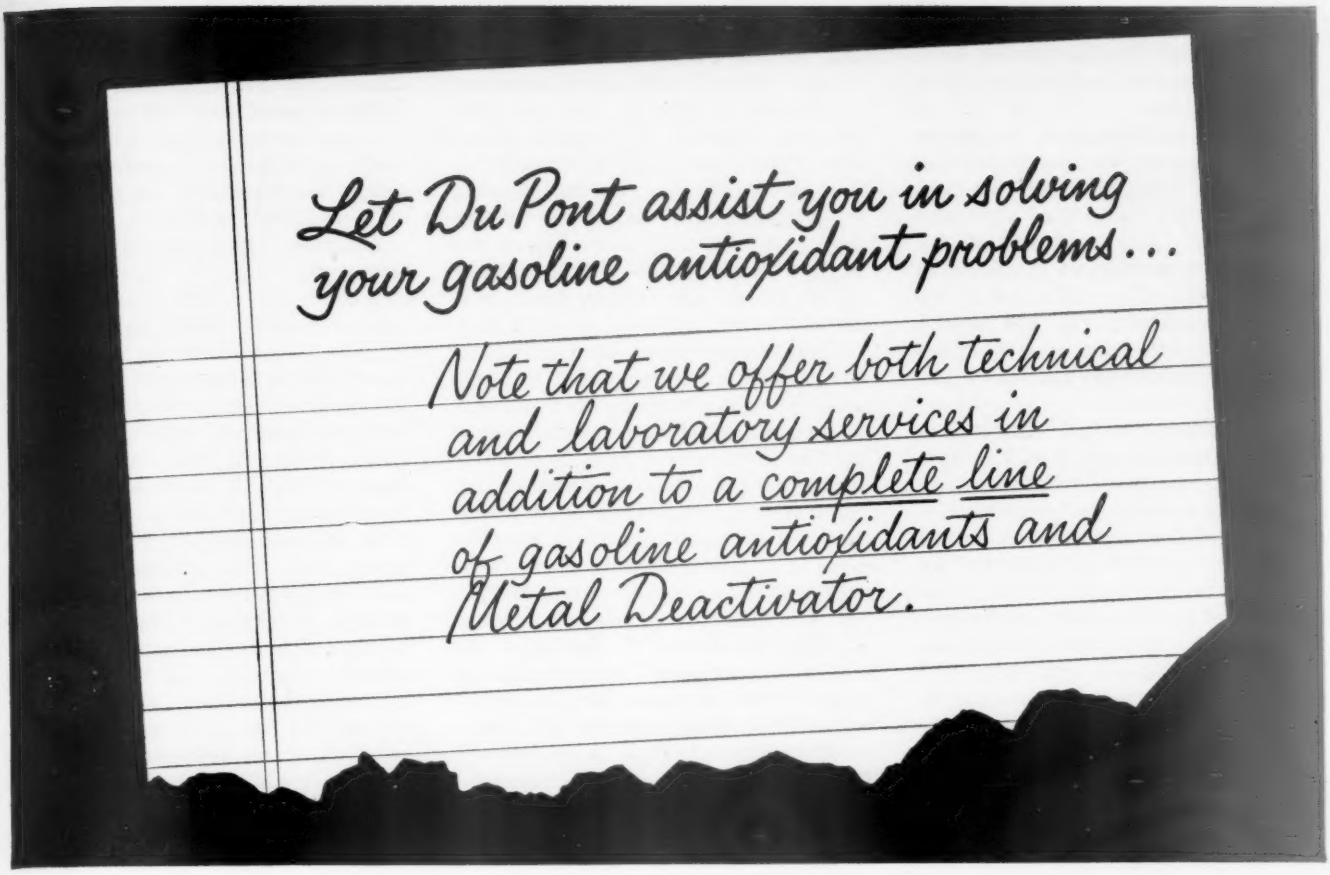


FIG. 2. Diagrammatic layout of waste disposal system.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steam driven ball valve reciprocating pumps through flexible suction lines. The skimmings are pumped to stop oil treating facilities.

The sides and bottom of the separator inlet, where duplicate facilities have not been provided, are lined with vitrified clay plates because of the intermittent acid characteristics of the waste. Each channel is coated with Nukemite 40. Counterbalanced flap gates are provided at the inlet to each channel to reduce venting of the sewer and thereby reduce the hazards of possible sewer explosions.

Grit Washer. The grit washer is a package unit designed for 350 gpm (Fig. 5). It consists of a channel 15 ft long having a trapezoidal cross section. The sides of the channel slope inward at 40 deg from 1½ ft at the top to 7 in. at the bottom. A 7 in. by 4 in. rectangular channel at the bottom serves as a track for the collection mechanism. Sand, gravel, cinders, and coke that settles to the bottom of the unit is moved by a chain scraper. The scraper washes and dewaters the grit as it elevates the material above the normal water level of the unit. The elevated relatively dry grit is dropped into a skid and disposed of as fill. The effluent from the unit flows by gravity to the auxiliary thickener where solids not removed in the grit washer are separated.

Pump Sump and Pumps. Waste water is pumped to the chemical treating section of the plant and to the storm water storage basin from a pump sump located at the outlet end of the grit and oil separator. The sump is reinforced concrete coated with Nukemite 40. Waste enters the sump via the sutro weirs at the end of the separator. The sump may be divided into two sections by a 6 ft by 4 ft gate. Each section has a 12 mgd pump for dry weather flow and a 67 mgd pump for storm flow. All pumps are vertical axial flow type. The draft tube, guide vanes, and impeller of these pumps are constructed by Everdur to resist corrosion.

The two storm water pumps and one dry weather pump are driven by steam turbines. The dry weather pump normally used is electrically driven through a variable speed hydraulic coupling. The pumping rate of all pumps is automatically controlled by the water level in the pump sump. For control purposes, each pump is allocated 6 in. of water level in the sump as an operating range. As each pump reaches a predetermined maximum capacity, the next pump automatically starts operating. Thus the pumping rate is maintained equal to the flow to the plant within the capacity of the pumps.

The procedure is reversed; i.e., each pump shuts off at a predetermined minimum capacity, as flow decreases. The dry weather pumps feed waste water to the chemical treating units at a predetermined maximum rate of 19.2 mgd; i.e., twice the dry weather design flow. Pilot plant studies indicated that such flow rates could be handled using coagulant acids. Gates are provided in the sump to permit gravity flow to the storm water basin when the capacities of the pumps are exceeded (an estimated frequency of once in 10 years.).

Flow Measurement. Duplicate steel compartments are provided immediately ahead of the neutralization tanks to measure the flow to the chemical treating section of the plant. Waste water is conducted to this point from the pump sump via a separate 18-in. transite line from each of the dry weather pumps. A gate (normally open) connects the two compartments. Baffles are provided to reduce turbulence ahead of the measuring section.

Flow is measured and distributed evenly to the duplicate chemical treating sections of the plant by 3 ft weirs at the outlet of each compartment. Each weir discharges into a neutralization tank. Two floats in each compartment measure the head on the weirs. One pair of these floats serves a pneumatic instrumentation system and the other pair serves an electrical instrumentation system. Four transmitters, 2 electrical, and 2 pneumatic are mounted directly above the floats.

The electrical transmitters control in proportion to flow the percent of the time power is available to flex-o-timers in the Cyclator sludge draw-off system. Each pneumatic transmitter sends air signals to an air relay summation unit where the signals are added and a derived signal proportional to total waste water flow is transmitted to the following locations.

1. Conoflow positioners controlling the output of aluminum chloride feed pumps.
2. Conoflow positioner controlling the tree-o-control unit for the activated silica system.
3. A positioner controlling the feed rate of the alum feeder.
4. A positioner controlling the speed of a motor on the automatic compositing sampler.
5. A flow recorder on the main instrument board.

Neutralization Tanks. The neutralization tanks are designed to provide a 4 min detention at design flow. This detention time is based on laboratory and and pilot plant experience for neutralization to pH 6.9. Each of the duplicate sections is constructed of steel coated with Nukemite 40 and consists of two chambers approximately 10 ft sq having about a 10 ft water depth. The two chambers in each section are separated by an underflow baffle. Each chamber is provided with a vertical baffle on each wall and a 10 hp top entering turbo mixer. Lime slurry, under automatic pH control, and, at times, water treating sludge are used as neutralizing agents.

Cyclators. Flocculation, clarification, and sludge concentration is carried out in two duplicate package units bearing the proprietary name cyclator (Fig. 6). Each unit has an inside diameter of 100 ft and a side water depth of 13.5 ft. The bottom and the foundation of the mechanism is constructed of reinforced concrete. The sides and mechanism are of steel construction. Waste water flows to the units through 30-in. diamter lines from the neutralization tanks. The influent enters each unit centrally at the bottom and flows through a distributor into a circular reaction chamber constructed concentric with the unit.

Coagulation chemicals are added at this point along with secondary lime under automatic pH control. A rotor, which is actually a combination mixer and low head pump, mixes the chemicals and waste water with several times their volume of recirculated floc suspension and pumps the mixture vertically into a flocculation chamber. Well mixed floc suspensions overflows this chamber and passes under a baffle and out into the clarification chamber. Clarified effluent leaves the unit via two circular launders, one at the periphery and another 13 ft from the periphery. Four scraper arms which slowy rotate in the clarification chamber aid in thickening the settled floc and at the same time move the settled material to two sludge hoppers located near the center of the unit.

An additional 3½ ft of depth was added to the units to permit thickening and storage of 13 tons of sludge (dry basis) at a 2 per cent concentration. Intermittently, in accordance with a predetermined cycle and in proportion to flow, sludge is withdrawn from the hoppers by gravity to a sludge sump.

The cyclator units are designed for an overflow rate of 0.5 gpm/sq ft at design flow. Pilot plant studies indicated that satisfactory results could be obtained at this rate using coagulant aids 40 per cent of the time or less. These studies also indicated that for average wastes, the rate could be doubled by employing coagulant aids.

An additional launder was provided 13 ft in from the peripheral launder to reduce vertical velocities at the launders and thereby prevent carryover of settled sludge. In this position, the inside launder circumscribes approximately ½ of the overflow area. The

design weir overflow rate is 6 gpm per lineal foot.

Orifices are provided in both launders to minimize the influence of head differential normally experienced in the use of exceptionally long weirs. Rectangular weirs, inserted at regular intervals in place of orifices, are each designed to discharge the same quantity of water as a single orifice at design flow. They are provided to prevent dust and debris from accumulating on the water surface.

Chemical Feeding and Handling. *Lime System*—The lime system was designed to satisfy the daily lime requirements 99.9 per cent of the time, as determined from pilot plant experience. This rate is 30 tons per day. Dolomitic pebble lime is stored in a 150-ton capacity outside tank. This tank was sized on the basis of receiving two 50-ton box cars at a time. Two 6-ton tanks are provided in the building, each directly over a 1100-lb per hr Omega gravimetric feeder and slaker. These tanks were sized on the basis of an estimated daily requirement of 4.4 tons. Slaking is started and stopped by the level in two 6450 gal slaked lime storage tanks located directly below each slaker.

Turbo mixers are provided in each tank to keep the lime in suspension. Slaked lime is fed to the neutralization tanks and cyclators under automatic pH control via a 100 gpm recirculation system which returns excess slurry to the storage tanks. Normally, a 1 lb per gal slurry is used. However, a 2 lb per gal slurry may be used when necessary. Saunders type valves with neoprene diagphragms are used as control valves.

Aluminum Chloride System—Aluminum chloride is used as a coagulant because it can be obtained economically from a spent catalyst sludge produced in the refinery. Recovery of aluminum chloride from the sludge is accomplished by hydrolysis. The hydrolysis equipment is designed to mix 100 gph of sludge with 300 gph of water to produce 315 gph of approximately 10 per cent aluminum chloride solution and 82 gph of hydrocarbon. The reaction is carried out at about 140 F in a glass lined jacketed hydrolysis mixer.

Separation of aluminum chloride and hydrocarbon takes place in a separator drum from which each component flows to respective accumulators. Recovered hydrocarbon is returned to the refinery via slop oil treatment facilities. Two 7980 gal accumulators are provided for the aluminum chloride solution. A 925 gal tank serves as a surge on the suction of the aluminum chloride feed pumps. All vessels in this service are glass lined. The sludge storage tank is lined with acid brick. Pumps are of hastelloy B construction and lines and valves are chemplas.

The expected coagulant requirement based on pilot plant studies was 100 ppm alum average; 1000 ppm maximum. Two plunger type chemical feed pumps are provided, each having the capacity to feed 500 ppm alum equivalent of aluminum chloride at design flow. The concentration is set by stroke length adjustment and maintained constant for flow changes by a PIV drive positioned by a Conoflow positioner which in turn is activated by the flow summation unit. The pumps discharge into a rubber lined flow splitting box which discharges equal quantities of aluminum chloride to each cyclator by gravity.

It was expected that the treatment plant coagulant requirements would not utilize all the aluminum chloride produced in the hydrolysis operation. To dispose of the excess, a glass lined mixer was provided where the aluminum chloride can be neutralized with lime slurry under pH control.

Alum System—An alum feeding system was provided for use at times when aluminum chloride is not available and when coagulant requirements exceed the capacity of the aluminum chloride system. Ground alum is stored in a 115-ton capacity tank outside. This tank was sized to store two 50-ton cars of alum. A smaller tank, 28-ton capacity, is located in the building directly over an Omega gravimetric feeder.

The feeder is designed to provide a coagulant concentration of 1000 ppm alum at design flow. Two variable speed transmissions drive the feeder; one is positioned manually to set the coagulant concentration and the other is positioned by a pneumatic positioner from signals received from the flow summation unit to maintain the desired concentration for variations in flow. Alum solution from the feeder mixing tank flows into a rubber lined flow splitting box which discharges equal quantities of alum to each Cyclator by gravity.

Silica Activation System—Silica activation employing sulfuric acid consists essentially of mixing definite proportions of sodium silicate, sulfuric acid and water, aging the mixture for a predetermined period and then diluting. Variations in concentrations and/or aging time result in the formation of silica gels or the formation of a poorly activated material.

The activation equipment was designed to produce activated silica practically instantaneously and to feed continuously in proportion to waste water flow. Conditions selected for activation resulted in a 15 min gel time and a 1.5 min design aging time. Capacity was provided to feed a maximum of 75 ppm at design flow. Average requirements were expected to be 10 ppm. It was expected that silica would be required 40 per cent of the time for normal flow rates.

A 17,000 gal heated tank is provided outside for sodium silicate storage. Sulfuric acid is stored outside in a 1760 gal tank. Two running tanks are provided inside; a 320 gal tank for sodium silicate and a 45 gal tank for sulfuric acid.

The activation equipment consists of proportional feed pumps, a mixing tank where the three components are thoroughly mixed, and an aging tank. The aging tank is constructed so that the detention in the tank is approximately proportional to the flow rate of the three components. Effluent from the aging tank drains to a dilution box where secondary water is added to stop the activation. Two equal flows leave the dilution box and flow by gravity to the cyclators.

Three air driven plunger type proportioneer's pumps feed sodium silicate, sulfuric acid, and water for silica activation. The pumps are manually set to feed proper proportions of silicate, acid, and water. Feed is maintained proportional to waste water flow by means of a series of control devices. Air impulses are received from the air relay summation unit by a Conoflow positioner which controls a Graham drive. The Graham drive in turn drives a treet-o-control unit through a torque converter. The treet-o-control meters the air to the three feed pumps. The desired activated silica concentration for treatment is manually set on the torque convertor.

Clay System—Ground clay is used as a weighing agent at times of high flow or when the waste contains a high concentration of oil. Spent clay from refinery operations is used for this purpose. A Raymond hammer mill and cyclone classifier are provided to grind the spent clay so that 95 per cent passes a 200 mesh screen. A 90-ton capacity tank is provided outside to store unground clay. Ground clay is stored in a 23-ton tank located directly over an Omega gravimetric feeder.

Clay enters the gravimetric feeder through a rotolock feeder which prevents flooding. Clay slurry from the feeder mixing compartment discharges into a division box from which equal quantities flow to each cyclator by gravity. The rate of clay addition is adjusted manually. The clay feeder is designed to feed at a maximum rate of 2000 lb per hr, which will provide a 300 ppm concentration during maxi-

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mum flow conditions; i.e. 19.2 mgd. A 500 lb per hr clay mill was provided since clay is expected to be required about 16 per cent of the time.

Pneumatic System. Lime and alum are received in box cars and clay in trucks. A Dracco pneumatic system was provided to transfer these materials from box cars to outside storage tanks and from the outside tanks to operating tanks inside. The system was sized to handle 8 tons per hr so that a 50-ton box car could be unloaded in a standard working day.

Sludge Handling System. *Sludge sump and pumps*—The floc settled in the clarification section of each cyclator is withdrawn under hydrostatic head (4 ft) into a sludge sump. The sludge drains to the sump through 4 pneumatic valves automatically controlled by a flex-o-timer. The timer contains an electrical mechanism to vary the frequency of drawoff in proportion to total plant flow.

The contents of the sludge sump are pumped by two 300 gpm power driven triplex ball valve plunger pumps to a sludge storage tank. The pumps operate intermittently by automatic float control.

Sludge Storage Tank—Sludges, originating in the grit and oil separator; the cyclators; slop oil treatment; ship cleaning operations; tank cleaning operations and other sources, are blended in a 44,500 gal sludge storage tank. Previous to blending, some of these sludges are thickened in the auxiliary thickener. The covered sludge storage tank is provided with heating coils using exhaust steam designed to maintain the tank contents at 140 F under design flow conditions. The tank contains a picket fence type mechanism and a bottom scraper for sludge blending and collection respectively. The tank was designed to accumulate 6 hours of normal sludge production. Sludge is pumped into and from the tank continuously so a liquid level indicator is provided locally and at the operation room instrument panel. A high level alarm has also been provided to prevent tank overflow.

Blended sludge is pumped from the tank to precoat rotary vacuum filters.

Auxiliary Thickener—A 50 ft diameter conventional thickener having a side water depth of 18½ ft was provided to handle miscellaneous sludges originating in various refinery operations. The unit has a central inlet and a peripheral launder for supernatant removal. An oil baffle is provided ahead of the launder and extends 7 ft below normal water level. A swing suction is provided to remove separated oil. A slowly rotating Hardinge scraper mechanism moves the thickened material to a sludge hopper from which it can be pumped to the sludge storage tank prior to filtration.

Water Treating Sludge Thickener—Water treating sludge is obtained from the hot lime soda treatment of boiler feed by several installations in the refinery. This material is pumped intermittently to the water treating sludge thickener at a rate of 200 gpm where it is concentrated to about 5 per cent solids content. The thickener is 20 ft in diameter and designed to store a one day accumulation of sludge. The thickened sludge is pumped by a power driven simplex plunger pump under manual control to the neutralization tanks, as a means of disposal. The sludge provides some neutralization and weighting action. Supernatant leaves the unit via a peripheral overflow launder and discharges to the sewer.

Vacuum Filtration—The sludge storage tank is the normal source of feed for four 18 ft long 10 ft diameter rotary precoat vacuum filters. Sludge is pumped by any of three 300 gpm ball valve (10-in. by 10-in. by 18-in.) steam reciprocating pumps. These pumps are controlled by the liquid level in the filter tanks. The temperature of the sludge to be filtered can be raised by the direct injection of steam into the feed lines.

The vacuum filters (Fig. 7) are precoated to a depth of about 3 in. with ½—1 per cent diatomaceous earth slurry. This slurry is produced by a National Foam Company inductor which aspirates the earth into a water stream. The diatomaceous earth is received by box car in 50-pound paper bags. The bags are manually emptied into a Redler conveyor which elevates the material to a hopper of nominal 60-bag capacity; i.e. enough to precoat 1 filter. The hopper feeds the precoat inductor by gravity.

A 3310 gal vessel is provided for holding filtered waste water which is used in the precoating operation. A 800 gpm pump recirculates this water through the inductor and recycles it after filtration. The precoating operation takes about 1 hour in which time 3000 lb of diatomaceous earth are laid down on the filter drum.

The vacuum filters permit 12 rates of knife advance for cutting precoat. The range is from 0.00065 to 0.00715 in. per revolution. Available filter drum rotation speeds vary between 78 seconds per revolution and 380 seconds per revolution. The piping arrangement permits one filter to operate on slop oil while any one or all of the remaining filters operate on sludge. The slop oil filter can also be used for sludge service. This filter is covered to prevent the escape of hydrocarbon vapors while filtering slop oil.

Three 3000 CFM reciprocating type dry vacuum pumps have been provided. Under proper conditions 1 pump will maintain vacuum on all 4 filters. Precoating, however, requires the exclusive use of one vacuum pump. A fourth steam jet vacuum pump is available for emergency use to hold cake on the filters in case of power failure. This pump starts operation automatically when the vacuum drops below 10-in. mercury. Vacuum is applied to the filters through an 8-in. diameter loop extending 34 ft above the filtrate receivers. This loop ties into the top of the filtrate receivers. Filters normally operate between 18 and 25 in. of mercury vacuum. A separate moisture trap-entrainment separator protects each vacuum pump from entrained water. Before venting to the atmosphere, gases from the vacuum pumps are scrubbed to condense hydrocarbon vapors.

Each filter is provided with a 2200 gal filtrate receiver. Filtrate is removed from these by two 400 gpm (7½-in. by 10-in. by 12-in.) steam driven reciprocating pumps. High level alarms are provided on 3 of the receivers. Liquid level control instrumentation is provided for the receiver serving the covered filter.

Each vacuum filter is provided with a conveyor belt discharging to a trunk conveyor. The capacity of the trunk conveyor belt is 6 tons per hour. All belts are made of Hycar. A sludge weighmeter weighs and totals the material on this belt. Filter cake is normally conveyed to an incinerator inlet hopper. It can also be diverted, however, to a concrete storage bin from which it may be returned to the incinerator by a traveling ½ cu yd clamshell bucket. The bin is of sufficiently large capacity to store a one week accumulation of sludge.

Incinerator—The filter cake contains sufficient hydrocarbon to be combustible. Sufficient heat will be produced to sustain combustion and produce steam. The incinerator has a rotating hearth 25 ft in diameter with an overhead Dutch-oven type boiler housing (Fig. 8.) The hearth may be rotated at 2.4 to 6.6 rpm. Its capacity is rated 4.35 tons of filter cake per hour.

On the hearth, four stationary rabble arms plow the burning material toward an outlet at the periphery. A cylindrical firebrick lined ash hopper under the hearth receives the ash. Forced draft for combustion is provided by a 12,000 CFM combustion air blower.

A multiclone collector has been installed on the flue to prevent fly ash problems. An induced draft fan compensates for draft losses. A 600 hp 200 psi water tube boiler is provided

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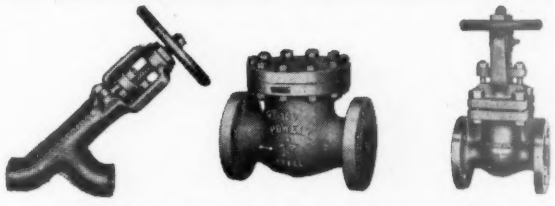

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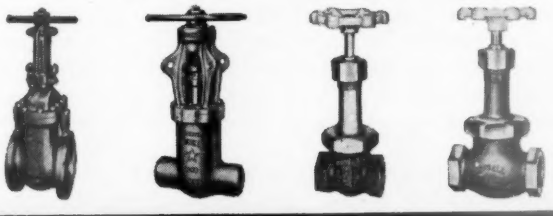

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with the usual sight glasses, safety valves, level alarms, soot blowers, liquid level controls, steam flow meters, and other accessories. Boiler feed water is obtained from a refinery boiler water treating plant and is pumped into the boiler by either an 80 gpm electrically driven two-stage centrifugal feed pump or by a steam turbine driven 80 gpm two-stage centrifugal feed pump spare. Both pumps operate under liquid level control. Provision is made for bleeding phosphate into the feed water for internal boiler feed water treatment. Flue gases discharge through a 150 ft stack.

The temperature of the hearth is controlled automatically by use of excess air provided by the combustion air blower. This blower is capable of providing 150 per cent excess air. For start-up, heavy fuel oil is used. A heated storage tank, reciprocating pump, and steam heater is provided to supply heated oil to four burners spaced radially around the hearth.

Ash Handling—Ash is obtained from the main ash hopper, from four hoppers under the boiler, and from a hopper under the multiclone collector. A steam exhauster provides air suction to transport this ash to an elevated ash bunker. The ash, fluidized with atmospheric air flows to two cyclone seperators in series on the top of the ash bunker. These cyclones de-ash the air. This air then flows to the steam exhauster and is exhausted to the stack. Periodically, the entire system shuts down permitting the ash to fall through a trap door at the bottom of each cyclone into the ash bunker.

For the main ash hopper, ash handling is automatic. The system operates once per hour and shuts down automatically when all ash has been pumped. The other hoppers require manual attention for fluidizing the ash. Ash in the ash bunker is wetted with water sprays in a rotating drum while being discharged by gravity to a truck. This wetting prevents excessive dusting.

Waste Treatment Plant Building. The treatment plant building has two major sections: one allocated almost exclusively to vacuum filtration; the other housing the chemical handling and feeding equipment, control room, laboratory, office, and locker room. The latter section is laid out to facilitate gravity flow of dry and liquid chemicals.

A small enclosure, containing the bag filter equipment for the pneumatic conveying system, is located on the roof of the building. Below this, on the abbreviated fifth floor, is the screw conveyor for moving solids laterally to chutes leading to dry chemical storage tanks. This floor also contains a bag filter to receive ground clay blown to this point from the clay grinder. The inside dry chemical tanks are located at the fourth floor level. This abbreviated floor also holds small feed tanks for sulfuric acid, sodium silicate, and aluminum chloride solution.

All these chemicals pass by gravity flow to equipment located on the third floor. This floor, which is the major operating floor, contains gravimetric dry feeders, aluminum chloride feed pumps, silica activation equipment, aluminum chloride hydrolysis equipment, a laboratory, and the main control board.

The second floor contains an aluminum chloride seperator, office, locker room, and conference room. Two lime slurry tanks penetrate the first floor and extend to the ground floor.

The ground floor contains the lime slurry pumps, benzene and aluminum chloride accumulators, tranfer pumps, and the Lectrodryer for instrument air. A section of the first floor, at a somewhat higher elevation, is used as a storage room for bags of diatomaceous earth. The Redler conveyor is located in this room.

The vacuum filter section of the building consists of a ground level floor and a second floor. The vacuum filters are supported on piers on the second floor. Subway grating is provided at several levels around the filters, conveyors and filtrate receivers to facilitate operation. A filter room control board also is located here on an upper grating.

The ground floor level is occupied by vacuum pumps, filtrate pumps, the filter aid hopper, the filter aid inductor, the precoat pump, and the sand filters.

Effluent water system. Effluent water is used for the water requirements in the waste treatment plant. Treated water, flowing from the cyclators to the Schuylkill River, drains through a clarified effluent sump. Suction is taken ahead of an overflow weir in the sump. Three 350 gpm electric centrifugal pumps distribute water through the plant for the following requirements:

1. **Dilution water for the aged activated silica.**
2. **Vacuum pump cooling jackets.**
3. **Hydrolysis mixer cooling jacket.**
4. **Alum and clay slurry preparation.**
5. **Filtered water for:**
   a. *Lime slaking.*
   b. *Acid and silicate dilution.*
   c. *Aluminum chloride sludge hydrolysis water.*
   d. *Precoat slurry production.*

Two conventional pressure type sand filters supply the filtered water. They are 7 ft in diameter and 4 ft high. They are backwashed to the sewer manually by resetting a wheelwright valve. The filters employ perforated pipe type underdrains and are backwashed whenever the difference between the inlet and outlet pressure gauges exceeds 6½ lb. City water, refinery low pressure water, and refinery high pressure fire-fighting water are also available at the treatment plant.

Storm water storage basin. The storm water storage basin was provided to store storm water flows in excess of maximum treatment plant capacity (19.2 mgd) up to a one-year storm and to act as an oil separator for larger flows. The basin was superimposed on an existing separator and is approximately 400 ft by 240 ft overall. It has storage capacity for 2,700,000 gal. Inlet and outlet structures are reinforced concrete; remaining side walls are rip rap.

Waste is pumped to the unit by the storm water pumps via an inlet channel and apron. Flows in excess of basin capacity pass under an oil retention baffle and over a broad crested weir into an 8 ft outfall sewer discharging to the Schuylkill River. Five power driven 6 ft by 3 ft gates are provided in the weir wall to lower the level in the basin at times when gravity flow from the separator is necessary; i.e. for flows exceeding the 10-year storm. Waste remaining in the basin, following a storm, is returned to the grit and oil separator at a controlled rate.

Cost of Construction

The cost of construction of a plant such as that described above, exclusive of land, may be expected to range from $2,500,000 to $5,000,000 (1953 basis) depending on local conditions and details of design. The area required, exclusive of the storm water basin, is about 3 acres. The storm water basin occupies about 2.25 acres.

Manning the Plant

The plant is manned on a shift basis using four operators under the immediate supervision of a non-technical shift foreman. This foreman spends part of his time following other operation activities. The operators are titled: water treatment operator, sludge treatment operator, control operator, and utility operator. Their duties are as follows:

The water treatment operator has oversight supervision for the entire plant and personally operates the waste water pumps; the chemical handling, aluminum chloride hydrolysis, and neutralization equipment; the cyclators, and the clarified water system.

The sludge treatment operator operates all sludge handling facilities including the pumps, thickeners, vacuum filters, and incinerator.

The control operator performs es-

sential laboratory control tests and assists the other operators as needed.

The utility operator lubricates equipment, makes chemical transfers, performs housekeeping duties, and assists the other operators.

In the daytime, a utility man handles the unloading of chemicals, the dumping of diatomaceous earth for precoating the vacuum filters and good housekeeping duties.

Although the operators are well occupied, it appears that four operators can adequately handle the operating work load at this plant.

The handling of dry chemicals and treatment sludges is a very dirty operation. At this particular time, several men per day are required for plant clean up. Changes, under consideration but as yet incomplete, should reduce the manpower required for this purpose.

The overall supervision of the plant is under the direction of a technical process foreman who is a day worker and reports to a general foreman in charge of all waste control operations. Plant maintenance is performed by personnel of the mechanical department of the refinery and is coordinated by waste control's operating maintenance foreman, under the general supervision of the maintenance foreman of the operations section.

Technical assistance to the operations group is provided by the technical section of waste control. During the start up period, additional assistance has been obtained from the engineering and construction and research and development departments of the company.

The men operating the plant were selected from the operating section of waste control which up to this time operated only the plant sewerage system, the oil separators, and the slop oil treatment facilities. None of the men now operating the plant had any familiarity with the processes or equipment used at this plant. Therefore, it was necessary to provide an intensive training course for the men and their immediate supervisors.

The technical section prepared a formal training program under the guidance of the training section of the personnel division. Training manuals were prepared describing the basic flow systems of the plant, using descriptive material to outline the basic principles and objectives of the process, and using flow diagrams, large detailed drawings, photographs, and vendors prints and instruction manuals to illustrate detail.

The shift foremen were trained first. They were required to perform laboratory experiments to become familiar with important process and variables and to run small pilot plant equipment to learn of the variables of chemical flocculation and vacuum filtration. They visited the plant under construction regularly and visited plants in the neighboring area to observe the operation of individual pieces of equipment similar to those to be used in the plant. After a thorough indoctrination in fundamentals, the shift foremen were assigned the job of writing detailed job breakdowns for every routine operation. About 30 working days were spent in class room and field training and about 30 working days were spent in preparing the job breakdowns.

The operators were given a 15-day course in fundamentals by technical section personnel. Then they were turned over to the shift foremen for detailed operation training using job breakdown manuals and on-the-job training. All operators were required to pass written tests on fundamentals and were required to satisfactorily execute dry runs on plant equipment.

The plant was started in operation in stages to restrict the scope of activities until the operators demonstrated complete knowledge of each new operation.

Four months of operation has substantiated the wisdom of providing good training prior to starting plant operations. It has also demonstrated that there is an acquired art or feeling for the various process operations which can be obtained only by doing. It will probably take three to six months longer before all operators acquire enough know-how or feel for the process to assure consistently good operation.

Start-Up Problems

Problems associated with the start up of the plant included those commonly encountered in any new plant, i.e., foreign matter in lines, faulty equipment, faulty installation of piping, valves, electrical wiring, controls, gear reducers, etc. In addition, specific problems of a design and/or mechanical nature were also encountered. A brief discussion of these problems follows.

Waste water flow and quality. The dry weather flow to the plant has averaged about 12.9 mgd which is 34 per cent above the design capacity of 9.6 mgd. Extensive studies have indicated that approximately 50 per cent of this excess may be due to infiltration in older plant sewers which previous to the plant start up had been surcharged. This had been anticipated so facilities were provided to raise the level in the sewers up to ground water level by the installation of a dam. The remaining 50 per cent appears to be due to additional process flow. Studies are in progress to locate the sources of these additions.

The oil content of the waste water not susceptible to separation averaged about 250 ppm, during a test run period. This is about 80 per cent of the total oil concentration originally expected in the separator effluent.

These conditions contribute to the relatively poor quality of effluent leaving the separators. High oil concentrations in the flow entering the chemical treatment section of the plant have resulted in high chemical requirements and poor settling in the cyclators. Since plant effluent is used as process water in the plant (section 3), a poor effluent quality affects equipment performance and thus a vicious circle is formed.

Grit and oil separator. Initially, some difficulty was experienced in pumping grit from the separator. Closed impellers were mistakenly provided on the pumps and proved very unsatisfactory. Open impellers have been substituted and operate satisfactorily. Excessive wear of pump shaft sleeves has been corrected by the installation of flushing water to the glands. An auxiliary supply of high pressure water connected to the pump suctions has been successful in clearing occasional blockage.

Considerable breakage was experienced with the high silicon iron pipe used for the grit removal system. Much of this difficulty occurred as a result of tightening flanges to stop leakage and probably was due to inexperience on the part of workmen and to some extent, to poor installation. Use of bell and spigot pipe may have prevented some of these problems. Steel pipe and fittings have given no trouble in 10 months operation as replacements for the high silicon iron.

The facilities provided for removal of separated oil have not performed as well as expected and undoubtedly contribute to the high oil concentrations in the separator effluent. The position of the automatic baffle and skimmer is somewhat affected by the quantity of liquid in the trough resulting in undesirable elevations of the skimming weir. The effect of this condition was somewhat improved by replacing the rectangular skimming weirs with triangular weirs, so that flow into the trough was not as sensitive to variations in the head over the weir. To further facilitate oil skimming, it is planned to control the skimming pumps by the level in the trough. Currently the pumps are manually controlled, resulting in the trough intermittently being pumped dry or being flooded. It has been difficult to maintain a tight seal between the skimmer and the side walls of the separator.

XUM

Floating debris passing through the bar screens has resulted in plugging the skimming pumps and pump suction lines. The clearance in the pump valves is only about ½ in. Work is in progress to install ¼ in. mesh double pot strainers on each pump suction and 1 in. mesh strainers on the skimmer trough.

Original pistons and rings on the skimming pumps have worn rapidly due to the abrasive nature of the skimmings. Darcova assemblies have been used successfully as replacements.

Cyclators. Circular troughs to remove scum in the inner draft tube have not proven satisfactory. Triangular weirs installed in the sides of the troughs have not corrected the problem as scum does not move readily to the troughs.

At times of cyclator upset, considerable sludge rises to the surface between the outer draft tube and inner launder. This material deteriorates the effluent quality by flowing through the rectangular weirs provided in the launder to keep the surface clean. Temporary upset cannot be completely avoided. Therefore, a rotating surface skimmer will be installed to remove this material.

Indications are that the welded joint between the cyclator deck plates and draft tubes is not tight. Air escapes through openings causing undesirable turbulence in the settling zone. This will be corrected when the units are next shut down.

The sludge draw-off piping and valves above grade must be steam traced to prevent freezing. This is because of intermittent operation.

Chemical feeding and handling. *Lime*—After about 3 months operation, the chilled cast iron agitators in the lime slakers became so badly worn that they no longer provided adequate agitation. This led to blocking in the slaking compartment and poor lime slurry quality. Ni Hard has been recommended for replacement.

The lack of scrupulous care in keeping the gravimetric feeder belt assembly clean led to uncorrected increased tare weight, giving lower actual feed rates than indicated. As a result, excess water was used in slacking and a poor quality lime slurry was produced.

The electric motors used to drive the turbo mixers in the lime slurry storage tanks were found to be slightly under capacity. A small reduction in impeller diameter corrected this situation.

Some blockage has occurred in the lime slurry distribution system, particularly where there are comparatively long runs from the control valve at the recirculation header to the cyclators. Work is under way to eliminate these long gravity runs by extending the recirculation header.

Considerable difficulty has been experienced with the Saunders type control valves on the lime feed system. Due to the rather large range required of these valves, they are necessarily ovrsized for average lime flows. As a result, they normally operate about 25 per cent open, causing rapid erosion of diaphragms and seats due to high velocities. Diaphragms of neoprene and natural rubber have proven unsatisfactory. Studies are continuing on diaphragm materials. In addition, a modified plug valve is being tried.

Alum — Problems associated with alum feeding have resulted from the contamination of alum with unslaked lime in the storage tanks. This has produced a relatively hard setting mass in the feeder solution tank which had to be shoveled out. On one occasion a reaction between alum and the contaminating lime occurred in the small alum storage tank which liberated sufficient heat to blister the paint on the tank and formed a concrete-like mass in the tank. Several days work with power tools were required to remove this material.

Clay—Extremely rapid wear of the original manganese steel, clay mill hammers has been experienced. Studies in progress to find a suitable alloy for this service indicated approximately 80, 90, 100 and 110 hours equivalent service for manganese steel, work hardened manganese steel, stellite tipped and case hardened carbon steel hammers, respectively.

Considerable difficulty was encountered dispersing ground spent filter clay in water prior to feeding. The problem has been somewhat alleviated by using burned spent clay. The use of substitute weighting agents are under study. These include spent catalyst from cracking operations and ground ash from the treatment plant incinerator.

The clay mill has produced clay averaging 85 per cent through a 200-mesh sieve. This size appears to be satisfactory.

Activated Silica—The pressure of water supplied to the water feed pump was too variable to assure accurate metering. This was due to the poor quality of the water (plant effluent) and an improper choice of the pressure control device. In addition, no surge was provided on the suction of the water pump, causing severe water hammer in the plant water distribution system which resulted in rotameter breakage and joint leakage. Modifications are underway to correct these problems.

Aluminum Chloride—Considerable breakage was experienced with the chemplas pipe and valves used in the aluminum chloride hydrolysis system. Tight joints were difficult to secure with a relatively incompressible asbestos-filled type gasket originally used. As a result, much pipe was broken in an effort to stop leaks. The substitution of neoprene gaskets was an improvement. Some pipe was broken as a result of thermal expansion.

Valve body failure, both during installation and in use, was also common. Failure was reduced by removing the teflon seating sheets provided, and using the neoprene diaphragm backing to seat directly on the body. These diaphragms failed rather rapidly, particularly in oil and sludge service. Chemplas valves on tank outlets were replaced with glass lined steel. Current valve failures are replaced with Aloyco-20 gate valves. Studies are being made to determine suitable materials for pipe, valves and diaphragms.

Two small breaks in the glass lining of one of the vessels were satisfactorily repaired with tantalum plugs.

Diatomaceous Earth — The water for slurry production is controlled by filter vat liquid level through a level control valve located upstream of the precoat inductor. As the filtration rate decreased during the precoating operation the control valve began to cycle. This valve, when closed, trapped some pressure in the inductor, causing water to back up into the feed hopper, forming a cake and blocking up the hopper. The installation of a variable orifice in a by-pass around the inductor and the addition of a stop on the control valve stem to prohibit complete closing has eliminated this problem.

Pneumatic Conveyor System. Serious chemical contamination between alum and lime was experienced in operating this equipment. Study of the problem indicated that the stop gates to the various tanks could easily be bent out of shape preventing tight closure. Auxiliary gates were installed in the discharge line between the conveyor and the alum tanks to positively eliminate contamination. The results of contamination in other tanks have not been serious.

Some overloading of the screw conveyor drive motor has occurred due to material being carried past the discharge gates and collecting at the end of the conveyor housing. A relief opening has been installed at the end of the conveyor to relieve this condition.

The dumping of the dry chemicals from the screw conveyor into storage tanks had created a dust problem from the vents of these tanks. The installation of temporary bag filters on these vents has reduced the dust problem.

This does not, however, permit adequate air flow to prevent pressure build-up in the tank, which causes premature sounding of the high level alarms.

Sludge Handling System. The abrasive nature of sludges from the cyclators and particularly from the auxiliary thickener has caused rapid wear of the sludge transfer pumps. Failure of piston rings and scoring of pistons, rods and cylinder liners has occurred. Darcova cup assemblies have been installed on one of these pumps with good results. It is planned to modify the other two pumps in this manner and to install liners and rods made of an abrasion resistant alloy.

Control valves on the filter tanks are Saunders type having neoprene diaphragms with teflon seating sheets. These diaphragms have worn very rapidly and the valve bodies have shown appreciable wear downstream of the seat. Reductions in the pressure drop across these valves has somewhat alleviated this condition. A modified plug valve, however, is being tried as a possible substitute.

The bronze bushings in which the filter tank agitator pivot arm rides have worn out of round and have been replaced.

The sluice lines provided on the filters for washing plugged easily and were not constructed in a manner conducive to convenient cleaning. The holes in these lines were enlarged and countersunk and clean-out connections were provided.

The sludge conveying system has given considerable operating difficulty. The original belts were not oil proof and were soon attacked by the oil in the filter cake, resulting in nearly continual misalignment. Replacement with oil proof belting and installation of self-aligning roller guides in place of stationary pipe roller guides originally provided have reduced the alignment problem.

Spillage from the belts has been a serious problem. In addition to that due to misalignment, appreciable spillage has occurred at the feed points to the belts. Cake being cut from the filters bounced over the belt side skirts onto operating platform and the floor. Cake also spilled from the main belt at auxiliary conveyor discharge hoppers. Extension of side skirts and modifications of discharge hoppers has eliminated this type of spillage.

The stationary scrapers provided to remove cake from the belts have not proven satisfactory. Cake remaining on the belts falls off on the return flight, collecting on the floor and fouling the drive pulleys and idlers and resulting in belt misalignment. Means of a more positive cleaning of the belts are being investigated.

Vacuum Pumps. Water entering the vacuum pumps has caused failure of a piston in one pump and a piston and cylinder head in another. Barometric loops, high level alarms in the filtrate receivers and moisture traps have failed to prevent this occurrence. The high level alarms failed soon after start up, apparently due to turbulence in the filtrate receivers. Plans are under way to relocate the high level alarms outside the receivers and to provide additional water knockout facilities.

Incinerator and Boiler. Two major problems have been encountered to date in starting up the incinerator. One has been in retaining insulation on the stationary rabble arms. The problem there has been due apparently to inadequate expansion room in the keyed-brick type insulation. The brick cracked on several occasions and dropped on to the rotary hearth. A monolithic plastic insulation construction was substituted. Insufficient operating experience has been had with the arrangement to prove or disprove its worth.

The second difficulty has been encountered in removing the ash from the furnace. The throat of the steam jet exhauster which creates the vacuum on this system blocks after about 8 hours operation. The blockage occurs due to carry-over of very fine ash particles from the cyclone separators provided to remove the ash. The combination of heat, moisture, and solids cause a relatively hard cake to be built upon the walls of this throat, gradually reducing the evacuating capacity of the system to the point where ash could not be removed as fast as it was formed. A small stream of water has been introduced tangentially ahead of the throat to wash and cool the walls of the exhauster. No operating experience is available on this new arrangement to date.

Effluent Water System. The control equipment provided to maintain constant pressure in this system has presented a problem. Mercoid pressure switches which start additional pumps at times of high demand have caused these pumps to cycle rapidly under certain conditions. This rapid on-off operation has led to motor failure on two of the three pumps. Means of eliminating this condition are being investigated.

Operating Data

The plant has been in operation such a short period of time that it has been impossible to correct all of the initial operating problems. Many detailed mechanical problems, not vitally important individually, collectively have interfered seriously with operation. Essential equipment is frequently not available for use when badly needed. Just as often, the operators are occupied working out mechanical problems when they should be following operation variables. Therefore the data presented herein is not typical of a plant under complete operation control.

Screening. Trash and wax accumulates on the bar screens. The screens require cleaning about every two weeks and/or after each heavy rainfall. Nominal accumulations of wax are dissolved.

Oil Separation. Test runs have been made to determine the removal efficiencies of the separator under different conditions of hydraulic loading and waste water quality. From these studies estimates were made of the effective diameter of separable "suspended oil" droplets using the theoretical eddy diffusion formulations of Dobbins.[4] Such oil is defined as that oil remaining in suspension after one minute of quiescent settling and separating by 30 min of quiescent settling. It was arbitrarily assumed that the oil separating in one minute was free floating entering the separator. The median effective droplet diameter indicated by these studies was 0.012 cm. The separable suspended oil amounted to 40 per cent of the total separable oil.

The separator was designed in 1948 using Dobbins formulations for an 0.02 cm droplet diameter. The surface area provided is 1.24 times the area of first section of the API separator standard at that time. Subsequently, studies at Atlantic[2] and elsewhere have indicated that designs should be based on smaller droplets. The above studies have confirmed this. In no case were the removal efficiencies observed in excess of the theoretical calculated for an 0.02 cm droplet.

Grit Removal. The average quantity of grit collected during the past 10 months is about 22 tons per month. The maximum daily collection was about 8.5 tons. The analysis of the washed grit is as follows:

Constituent	Composition percent	
	Average	Range
Water	18.7	4.7—35.8
Oil	16.2	6.6—26.2
Solids	64.9	42.8—84.4

This material has been entirely satisfactory for disposal as fill.

Chemical Flocculation. When the cyclators were first placed in operation poor effluents were the rule and good effluents the exception. After 4 months of operation the reverse is true. Typical current operating data is shown in Table 1. This data is based on 10 days operating results. Each day spot samples were collected every 2 hours. Three sets out of these samples were selected

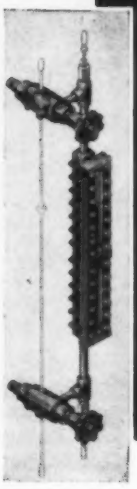

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TABLE 1. Chemical flocculation data.

	Flow mgd	pH ppm.	S.S. ppm	Turb. ppm	Oil ppm	C.O.D. ppm	B.O.D. ppm
Influent							
Number of tests	30	30	30	30	30	30	24
Average	13.4	8.1	187	114	616	2360	694
Median	13.3	8.3	107	91	426	2000	428
Range	12.4—14.8	4.5—11.6	12—1080	22—450	41—2540	550—15000	156—4100
Effluent							
Number of tests	30	30	30	30	30	30	24
Average		9.7	148	66	234	970	304
Median		9.9	50	24	34	440	160
Range		7.2—11.0	4—1340	4—570	3—4000	29—7050	65—2060
Percent reduction							
Number of tests	30	30	30	30	30	30	24
Average		—	—25.4	37.6	52.2	52.5	43.5
Median		—	50.4	79.0	89.0	75.1	62.3
Range		—	(-) 1060-96.9	(-) 433-94.5	(-)394-98.9	(-)234-98.7	(-)252-89.0

for analysis by chance using a shuffled deck of cards. A detailed analysis of the data revealed that inlet oil concentrations up to 1350 ppm had no effect on effluent quality. In two cases, where the influent oil concentration was 2500 ppm or more, the process was definitely upset. In one of these cases the effluent oil content was 4000 ppm.

The chemical use data for the test period is shown in Table 2.

Sludge Handling. Shown in Table 3 are the flow and characteristics of sludge charged to the filters and the cake discharged. The filter cake contains about 15 per cent more water than obtained during pilot plant investigations. It is expected that this can be reduced as more experience is obtained in the operation of the filters.

The limited data on incinerator operation indicates that one ton of sludge will produce about 7500 lb of steam. A small amount of supplemental fuel is generally required to maintain the desired 2000 F combustion temperatures. At times of low moisture or relatively high oil content in the sludge, supplementary fuel is unnecessary. High temperature control may be a problem at such times. The waste treatment plant described above was designed to provide satisfactory treatment for appreciable overload and to permit flexibility of operation for widely variable waste water quality. Preliminary operation data indicates that the design basis for the separator was short on factors of safety to meet all current operating conditions satisfactorily. The remainder of the plant has demonstrated adequate flexibility and capacity for overload.

TABLE 2. Chemical Use data.

Chemical	Average	Use median	Range
Alum (T/D)	5.1	1.8	0— 18.7
Aluminum chloride (T/D alum equivalent)	7.6	6.5	0— 16.1
Lime (T/D)	17.2	13.6	1.4— 21.4
Sodium silicate (gal/D)	701	763	0—1997
Sulfuric acid—98% (gal/D)	82	70	0— 261
Spent clay (T/D)	3.1	3.1	0— 6.3
Diatomaceous earth (T/D)	1.2	1.3	0— 3.0

TABLE 3. Sludge handling data.

Item	Average	Median	Range
Slude volume—gal/D	162,400	155,000	119,900—201,300
Sludge quality—percent			
Water	91.4	91.3	86.2 — 95.4
Oil	4.3	3.9	2.3 — 11.5
Solids	4.3	4.7	2.1 — 7.8
Gravity	1.010	1.009	1.000— 1.030
Filter cake weight T/D	63.4	67.7	15.9 —157.9
Filter cake quality percent			
Water	58.1	57.4	47.0 — 65.8
Oil	21.2	22.3	14.5 — 30.2
Solids	20.7	20.3	19.7 — 22.8
Ash	13.7	13.4	13.3 — 14.2

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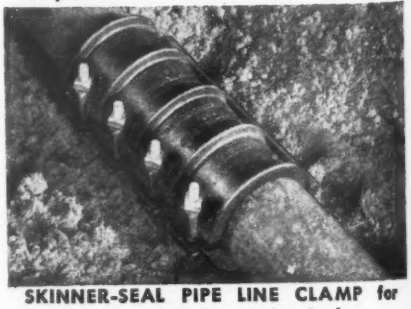

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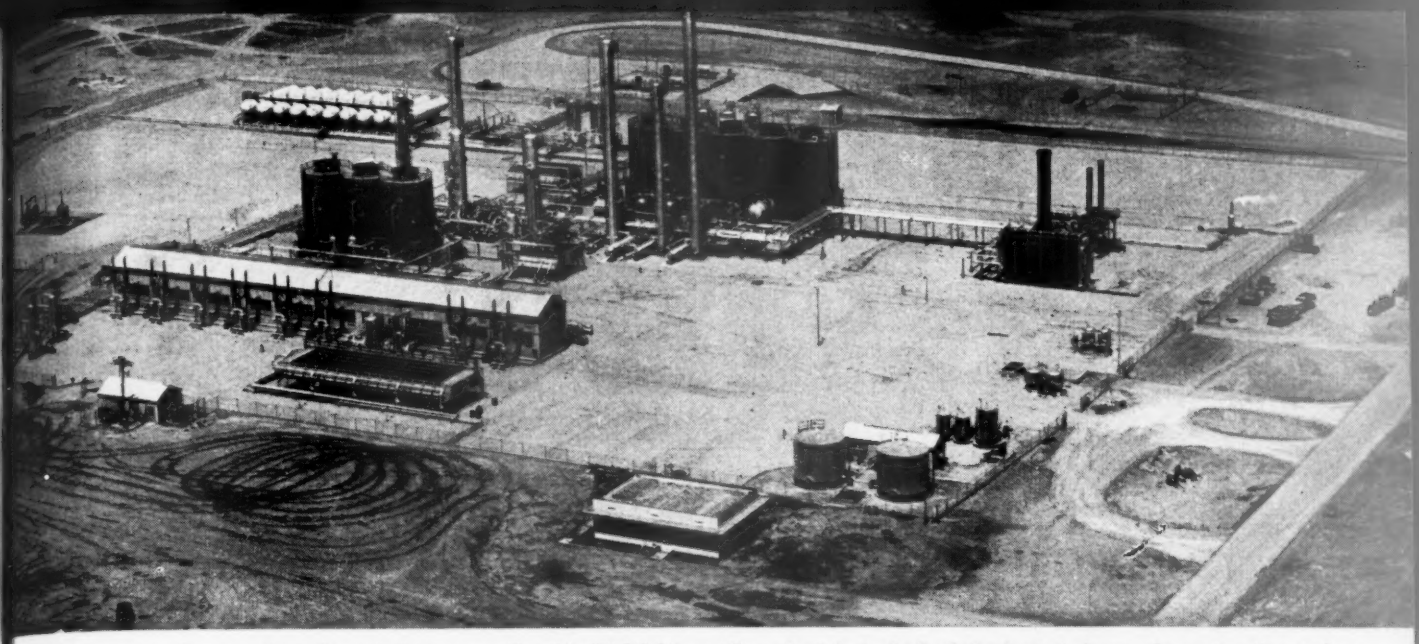

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P 702.

TAMING 'Wild' GASOLINE

Technological advances have revised the economic picture; end-use expansion has boosted consumption; fundamental problem yet to be solved.

ARCH L. FOSTER*

THE first "natural" gasoline recovery system was largely automatic and by natural means; the gas company merely provided a rundown tank to catch the gasoline after it had condensed in the line. "Drip Pots" were installed at intervals along gas pipe lines, into which the liquid "casinghead" gasoline could flow. The liquid was removed periodically from the pots. It was sold, whenever possible, to be added to motor fuel to help engine starting, especially in cold weather.

This "drip" gasoline was collected first, so far as written records are available to us, about 1903, by Sutton Brothers and Edmonds, at Sisterville, West Virginia. It was collected by putting cooling coils in pipe lines handling gas, and thus condensing the heavier components, probably "hexanes and heavier," and it was sold to augment both quantity and volatility of local motor fuels. Shortly after 1903, "Bill" Richards built a compressor recovery plant in Pennsylvania; said to be the first compression operation. Experimentation, meanwhile, was going on studying the absorption of heavier gas components by means of a heavier "mineral seal" oil. An oil absorption plant was built in West Virginia about 1913.

Progress in *recovering* these condensable portions of wet natural or casinghead gas continued rapidly. Rectification, or stabilization developments lagged behind woefully. The earlier products were "weathered," exposed in vented or open tanks, to allow the ethane and propane, with some butane, small amounts of pentane, etc. to escape. This of course was a most wasteful and runious method and better methods were developed, especially during the 1920's and later.

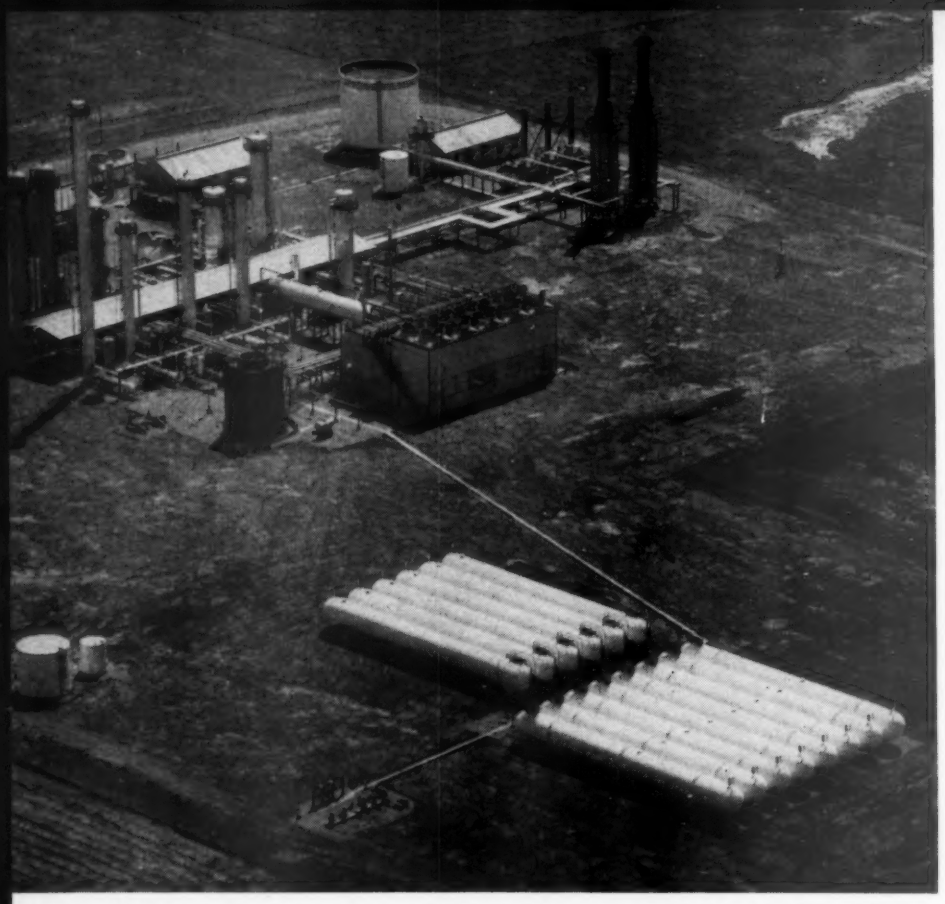
After World War I ended, work began on the use of charcoal to absorb the heavier wet gas components. It is believed that the first charcoal gasoline plant, which used horizontal absorbers, was built by James E. Pew for United Natural Gas Company near Bradford, Pennsylvania, in 1923. Many such plants were built but development of oil absorption processes oustripped charcoal, which had inherently lower efficiency and capacity. The charcoal process also required a cycle of alternate absorption and stripping, in the same column, whereas oil could be pumped through the absorber to be enriched by light products, sent to a still (another vessel where it was stripped of its aborbed material) and then be returned to the original absorber. The need for alternately heating and chilling the same vessel was thereby avoided.

Gradually oil absorption displaced charcoal. Compression of the incoming gas, with some condensation immediately after, was added to the natural gasoline plant design. Rectifying towers, actually fractionators operating under closely controlled conditions, were in rather crude design at first. The step eliminated the undesirable propane and as much butane as was not wanted. It also gave the proper vapor pressure to the finished gasoline, while allowing the minimum of the desirable component to escape with reduction of yield. Still later came outside refrigeration to liquefy propane, butane, and their mixtures along with pentanes and heavier, to thus recover a greater proportion of the propane and higher molecular weight hydrocarbons present in the gas.

Charcoal operations were most useful on large amounts of lean gas at low

*Editor, Refining, Petrochemical and Gas Processing.

EXCLUSIVE



A Mid-Continent ultra-modern gasoline unit, Cities Service's Ambrose plant in Oklahoma.

pressures, according to the notions of the late '20's and early '30's. Compression was for smaller quantities of rich gas, several gallons per 1000 cu ft; oil absorption was best for lean gas that could be processed at then considered higher pressures. In 1920 Emby Kaye wrote "Charcoal absorption is practically as efficient at these low pressures (5-20 lb), as at the conventional 35 lb at which oil absorption plants are operated. (*The Petroleum Engineer*, October, 1930, page 49). Compare this 35 lb with the hundreds of pounds pressure used in most plants in 1954. At that time also a plant that took all plant vapors or gases from the compressor discharges and in a "rectifying column" turned out a finished gasoline was attracting considerable attention. A debutanizer column of 15 trays was described at that time; it was prophesied that direct stabilization would find its way for the selective extraction and liquefaction of hydrocarbons from casinghead gas.

Advances were being made, however, in plant design and operating details. In Pure Oil Company's Van, Texas, gasoline plant in late 1930 raw gas was being metered into the plant, compressed to 300 psig by two-stage compressors, and the recovered compression gasoline was stabilized at 210 psig. The propane and as much of the butane as was required to obtain the desired vapor pressure or distillation range were sent overhead from a bubble tower stabilizer.

By 1936, fractionation was coming into its own rapidly; a multiplicity of towers were being installed in gasoline plants. Deethanization, depropanization, and debutanization were beginning to be practiced, although a "typical gasoline plant layout" of that vintage showed only absorbers, stills, and stabilizer towers as the main operating units.

About this period the tremendous job of developing a suitable method for determination of vapor pressure got under way. The Society of Automotive Engineers, the ASTM, the API, and NGAA, and CNGA organizations all collaborated more or less, and the work went on for years, with a stupendous amount of cooperative work in many laboratories. Phillips, Skelly, Standard of Indiana, Shell, Warren, Sinclair were some of the more active in the work.

Charcoal plants were on their way out; they offered good results in flush production areas with low pressures, but charcoal pulverized and lost capacity. The crude had to be removed so as not to damage the charcoal and air leaking into sulfur-bearing gas produced H_2S and sulfur that would deactivate the absorbent which then must be reactivated with caustic soda or the equivalent. At that time the only charcoal plants in operation were in West Virginia, where old plants could be operated more economically on the available gas than new plant for oil absorption could be built and operated. Recycling, "return of dry gas to the oil sand for repressuring," was being studied and employed to some extent, a development which inclined designers and plant operators to tend toward higher operating pressures.

During this long decade, when economic conditions were adverse to most developments, many of the fundamental and far-reaching advances in the industry's technology were made or begun. Such figures as Oberfell, Alden, Sid Smith and Ted Goebel, Emby Kaye and Jimmie Vaiden, Lederer, Chase, Bunn, the Thomases, Ross and Harry, and Buchanan—their work made indelible history for the industry. In a majority of instances that history is still being made by these leaders; some have gone to their rewards.

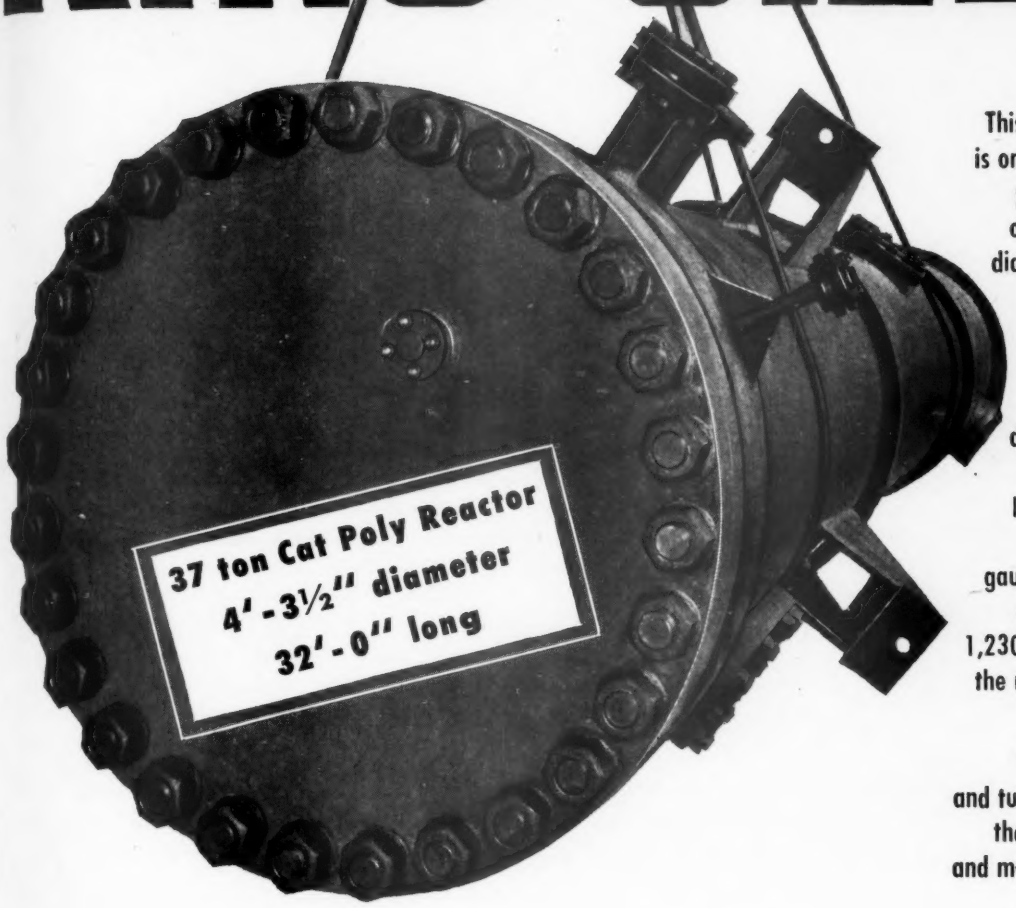
Present-day operating technology in natural gasoline would be recognized by the early pioneers in a measure, yet so much has been added that the old methods were an art, the 1954 technology an engineering science. Typical procedures now, and for approximately two decades, have been combination compression-oil-absorption processes. As gasoline plants have spread into the semi-arid parts of the country where cooling water is at a premium and where it is drawn from wells 10 to 20 miles from the plant, the use of air-cooling, using banks of small pipe cooled by a blast of air from motor-driven fans has come into prominent use, adding economy to good operation. Gas engine power and electric power, often generated on the plant premises, have replaced steam power in an increasing number of cases. Plants are operating now without a single steam boiler in sight.

Butane and pentane splitting have become the order of the day. A stream of combined C_4's or C_5's is sent to a separate tower, usually with 50 to 75 bubble plates to separate the iso- from the normal paraffin. The isoparaffin is used to produce such premium materials as alkylate by combination with olefins, or to make olefins as isobutylene, for butyl rubber, by dehydrogenation of the paraffin.

Combination absorber-deethanizer towers in one shell are becoming more common; one such tower is shown in Fig. 1. Ethane is knocked out of the rich absorber oil before the latter goes to the still, eliminating all or most of the work of a separate deethanizer tower. Actually this is two towers, the deethanizer superimposed above the absorber, in a common shell.

From a practical, economics viewpoint the practice of underground storage of liquefied petroleum gases is one of the major developments of the

KING SIZE



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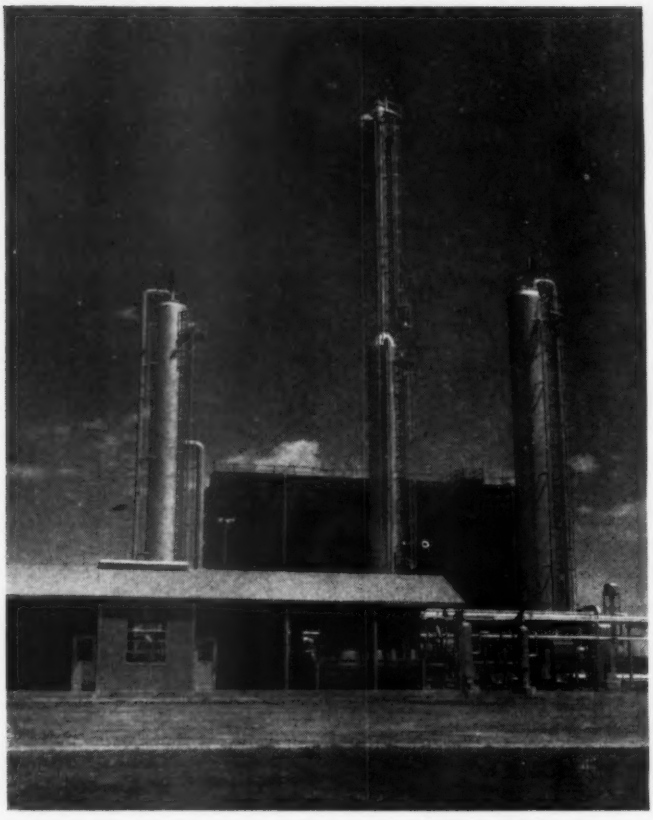
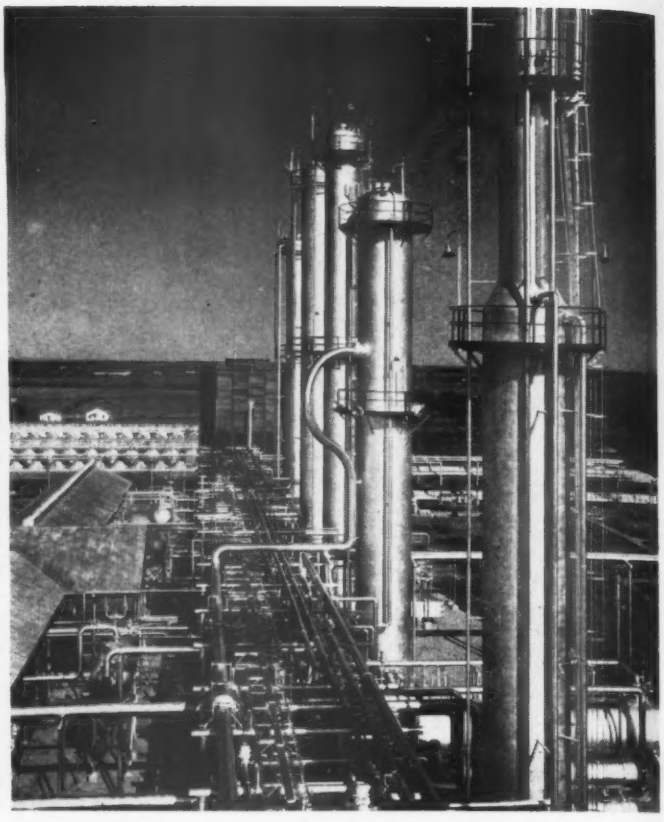


FIG. 1. The "last word" in tower design, in Kerr-McGee's Cactus plant, Texas; absorber-deethanizer tower in center.



The complexity of piping is a simple system only to the experienced engineer. Warren Petroleum-operated plant, Maysville, Oklahoma.

industry. LPG, as its name is abbreviated, as a marketable commodity dates back to the early 1920's. Bateman (*Petroleum Reference,* April, 1936, page 135), says this product got its start from Blaugas, developed in Germany about 1908, and used widely for a long time. During the next decade A. N. Kerr pioneered its slow and crude development. In or about 1920 Carbide and Carbon, pioneers in petrochemicals, started to make Pyrogen and Pyrofax, compressed and liquefied hydrocarbons.

About 1924, James E. Pew, now head of Sun Oil Company's natural gas and gasoline department, stopped building and operating charcoal gasoline plants to go to work for the old Hope Construction and Refining Company, devoting all of his time to testing the efficiency of the then current designs of natural gasoline plants, and also hunting new uses for propane. At that time most or all the butane produced was retained in the wild natural product, to plague the refiner-blender with vapor-locking fuel. The research carried on in this "epoch" laid much of the foundations for the embryonic LPG business-industry.

Frank Phillips then sicked George Oberfell and Ross Thomas onto the job of using the light stuff then being wasted as cheap fuel, and the show was on. Emby Kaye and Skelly Oil got into the play along with others in greater or less degree.

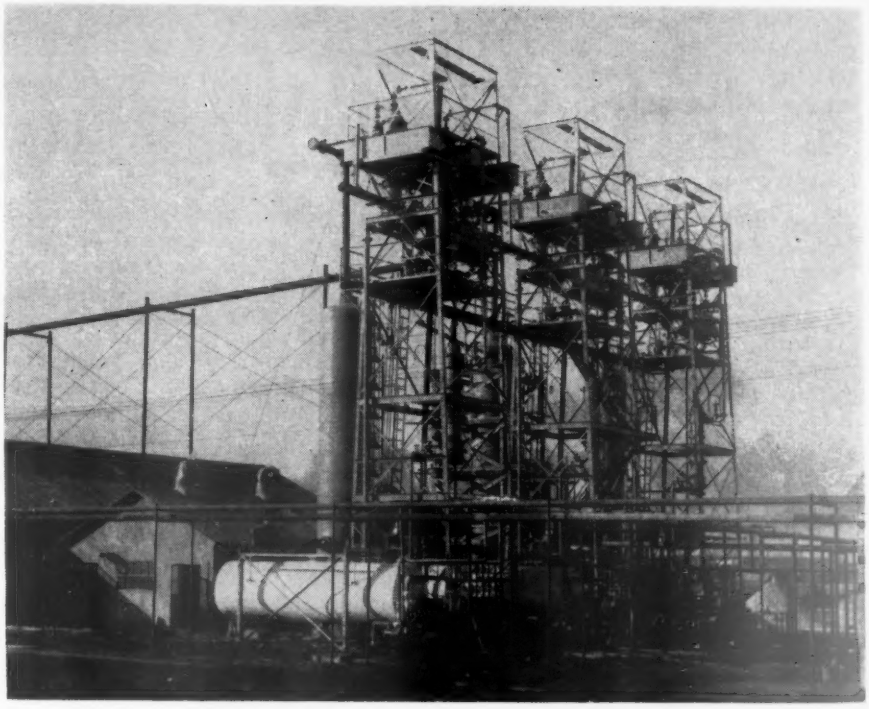
By 1930 the "butane-air" business was showing some signs of its possibilities. Kaye (*The Petroleum Engineer,* March, 1931, page 68) pointed out the advantages of the business for the interested investor-operator. He stated that the excess butane trying to find outlets was caused by the adoption of the very important natural gasoline specifications that had been set up shortly before by that industry. One company at that time was reported to own 16 of these distribution plants. The alertness of control instrument suppliers was indicated by the device already in use, that governed the amount of butane entering the mixture on the basis of the Btu of the mixture going to the lines.

Many engine operators became interested in using LPG as gas or gasoline engine fuel; dry gas was being used long since to fuel stationary engines. The outcome has been at least a half-dozen automotive fuel systems to be connected to the car and truck, tractor and bulldozer engines to supply vaporized propane, butane, and their mixtures to furnish automotive power.

The huge spread of the use of LPG, however, has been for domestic heating and also for industrial heating beyond the realm of gas lines. Pressure storage ranging in capacity from, say, five gallons to several thousand gallons has been developed by many of the LPG producer-marketers and engineering-fabricating companies to a very high degree of efficiency and safety. Systems were developed for supplying the product from tank trucks, better freight rates were obtained, health investigations were made, and municipalities were induced to relax ordinances prohibiting the installation of "bottled gas" inside village and city limits and a new industry was growing up.

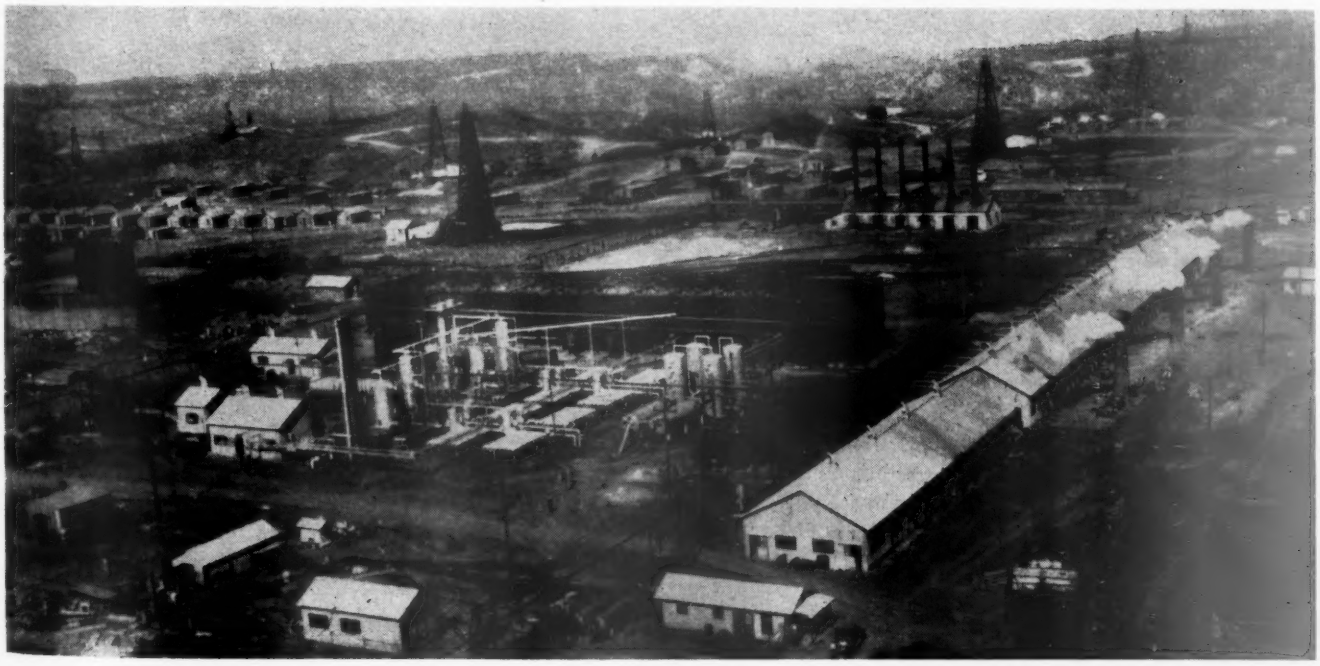
The larger consumption of LPG is seasonal; its occurrence in and separation from raw gas is not essentially as high in summer, the period of low consumption, as in winter, the period of greatest demand. And that is where underground storage comes in, although somewhat belatedly. Four years ago underground storage was a new, practically untried fantasy, unknown, full of potential pitfalls and costly mistakes. In 1954 (mid-summer) 140 caverns were in operation, with a total capacity of 11,600,000 bbl (487,200,000 gal) of LPG ("Status and Progress of Underground Storage, Doughty-Cole, Jr., Refiining and Petrochemical Edition, *The Petroleum Engineer,* September, 1954). These "caverns" included leached-out salt deposits, mined cavities, and depleted oil, gas, and water sands. Reduction in cost

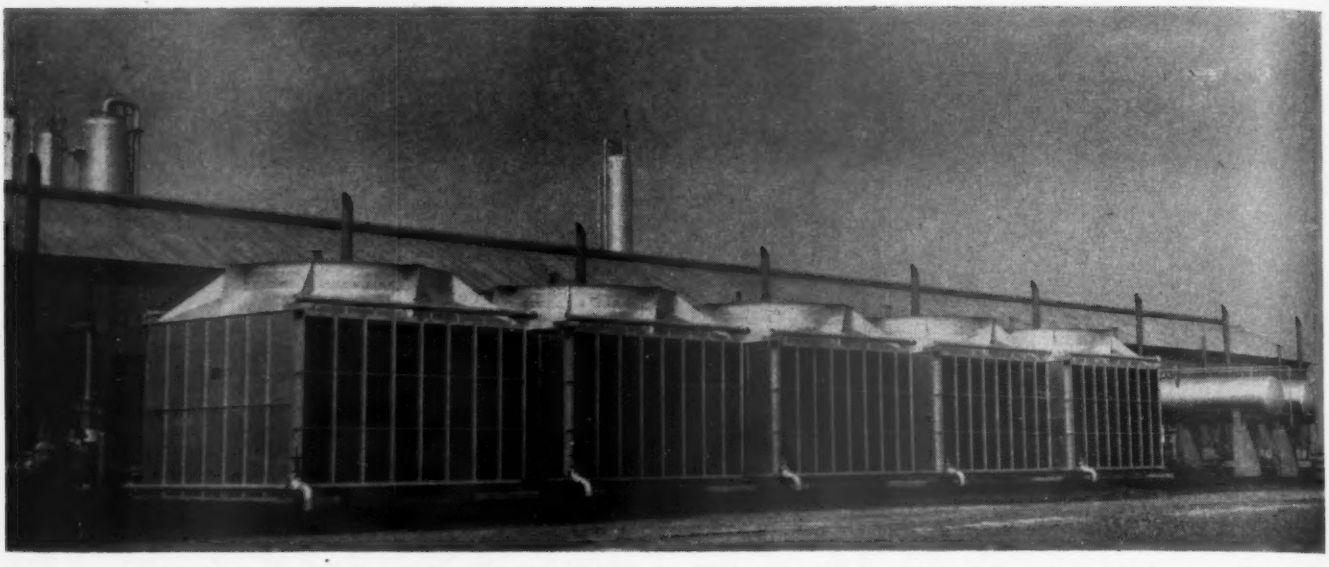
Phillips Petroleum Company's Burbank Gasoline plant, above, in Osage County, Oklahoma, started initial operations on April 12, 1922, and continued until May 1, 1935, after which it was operated as a booster station until March 10, 1950.



High pressure fractionators at Phillips Petroleum Company's DeNoya Gasoline plant in Osage County, Oklahoma. DeNoya plant began operation on September 24, 1922, and the high pressure fractionators began operations on January 1, 1929.

Phillips Petroleum Company's Pantex gasoline plant in the Texas Panhandle continues operating today after initial operations were begun June 24, 1926.





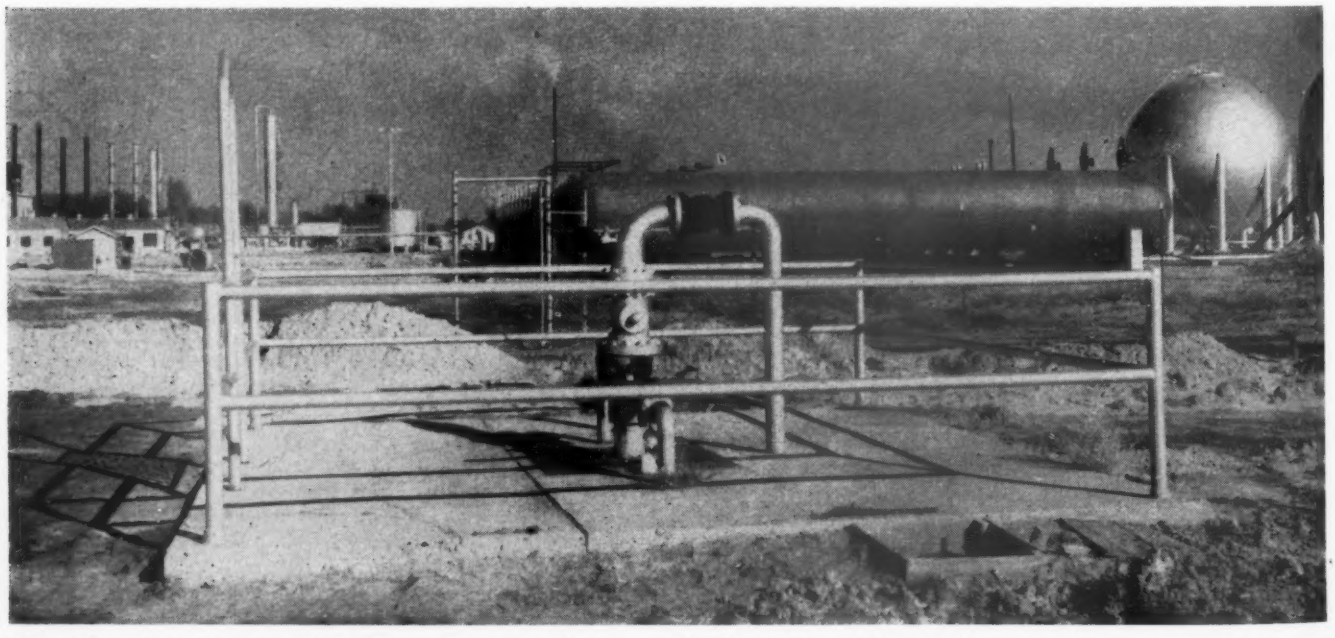
Water scarcity has been the "Mother of Invention," hastening the development of air coolers such as these, which are cooling compressor gas engine jacket water at Stanolind's Levelland, Texas, plant.

of this type of storage, the practicalbility of storing huge volumes inexpensively, and the permanent nature of the containers offers a most important consideration in the problem and economics of supplying consumers with this product at the lowest practicable cost and in the quantities required. Underground storage also helps conserve the LPG hydrocarbons produced with gas and /or oil during periods of low consumption.

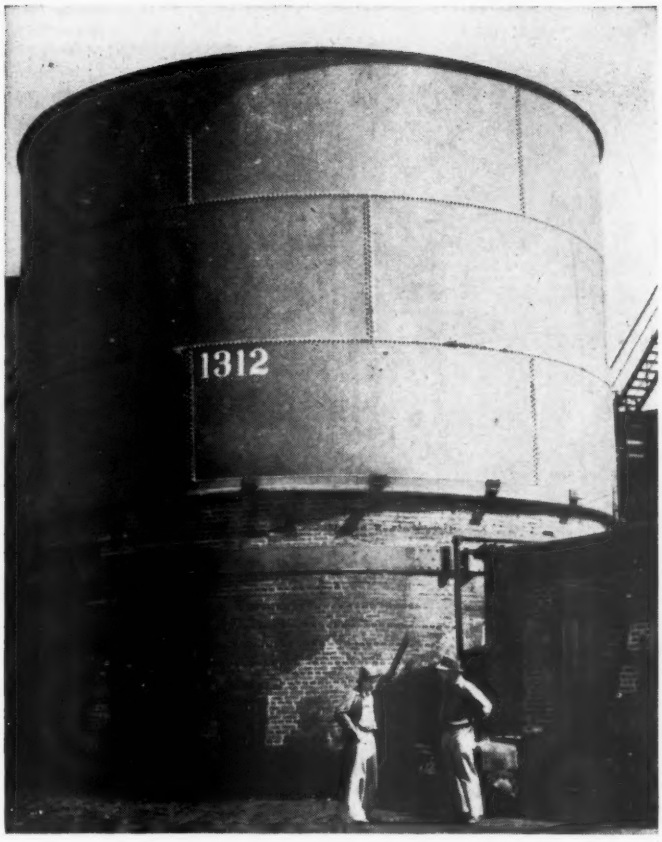
For the industry in general, advances in fractionation are among the most important technological developments. Some of these departures are new ideas and details in tray construction; some are new-old ideas, and variations of old notions. For example, (see Refining and Petrochemical Edition, September, 1954, for articles on several trays) back in 1936 J. A. Campbell discussed a new type of tray, actually a form of perforated tray, to be used especially in absorbers. This same principle has been discussed recently, though in differing details, and the perforated plate tray is being applied to an increasing number of uses (see Refining and Petrochemical Edition, *The Petroleum Engineer,* May, 1954, page C-21).

The assurance of steady supply of LPG, with production facilities smoothed out in their operation throughout the year, will boost consumption and the application of propane and butane to a greater number of uses in the future. This prospect is enhanced immeasurably by underground storage, made more economical by new methods of processing such as higher fractionation efficiency and refrigeration for liquefecation of these low-boiling constituents. The already tremendous rate of consumption of LPG (Refining and Petrochemical Edition, *The Petroleum Engineer,* January, 1954, page E-25) is amazing when we note that between 1945 and 1953, eight years, the total consumption was increased nearly 5-fold. Domestic and motor uses multiplied 6 times in that period.

Between 1947 and 1953 use of LPG for rubber component manufacture doubled, 200,000,000 to 400,000,000 gal. Between 1944 and 1953 chemical manufacture increased about 7 times. Among the outstanding and rapidly

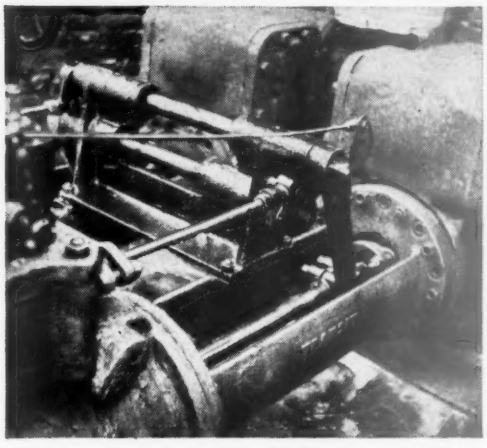


This shows all the structure that appears above ground on a multimillion-gallon underground storage cavern for LPG.; Warren Petroleum, New Mexico.



In this tank, where oils are treated with sulfuric acid, a coned bottom made of ½-inch Monel plate has successfully withstood corrosion since its installation in 1950.

Monel rods in acid sludge pumps at Atlantic's Philadelphia refinery last 10 to 12 months as compared to 5 months for brass or carbon steel. Service is severe since sludges must be steamed to increase their mobility.



Recent practice in

Controlling Dilute Sulfuric Acid and Acid Sludge Corrosion

When it comes to handling sulfuric acid and acid sludges in the refinery, there is a realm where neither lead, steel, nor copper-base alloys answer the equipment problem adequately. In such cases, the high-nickel alloys have often proved to have the most useful combination of chemical and mechanical properties.

For example, The Atlantic Refining Company had to repair a large outdoor tank used for acid treatment of light industrial oils. They wanted a better material for the coned bottom, in which deposits of acid sludge accumulate, and decided to try Monel. That was in 1950. The Monel was installed and has stood up without any need for repair ever since.

Similarly, when Atlantic found they were getting only 5 months' service from brass or steel rods in their acid sludge pumps, they substituted Monel. The Monel rods have been giving 10 to 12 months service. (Even longer service has been reported with heat-treated "K" Monel rods which also have greater resistance to scoring.)

Monel is also used in many refineries for valves and lines handling dilute sulfuric acid.

In general, Monel is used to handle sulfuric acid where a combination of good corrosion resistance and high mechanical properties—high strength and little or no creep—are needed. Its practical application is limited to reducing conditions and to concentrations below 80-85% at room temperature (or 12-15% in boiling solutions).

More information on controlling sulfuric acid corrosion is contained in Inco's Technical Bulletin T-3, "Resistance of Monel, Nickel and High-Nickel Alloys to Corrosion by Sulfuric Acid." It is yours on request.

And if you have such a corrosion problem, be sure to contact Inco's Corrosion Engineering Section. They will be glad to help you without cost or obligation.

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67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

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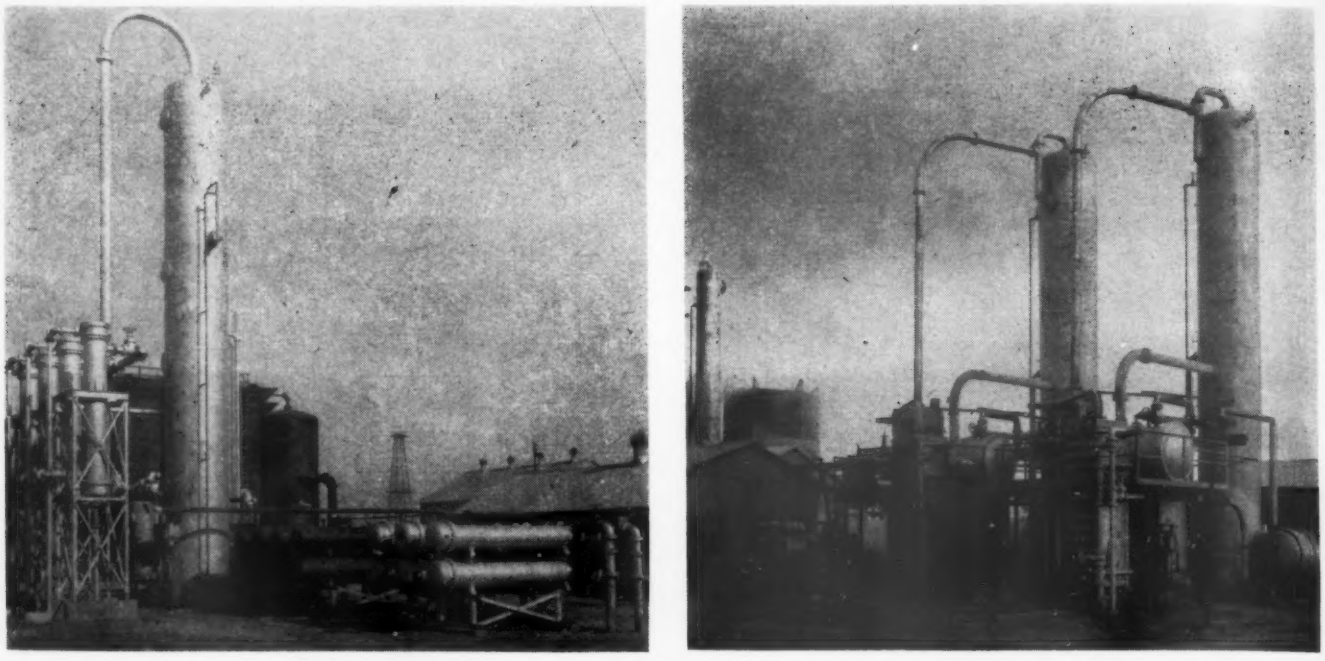
To obtain more information on products advertised see page E-57



Two early gasoline plants of Skelly Oil Company; the plant at King's Mill, Texas, left, and the Schafer plant of the same company both are dated in the 1927-29 period. The extreme simplicity of the design as compared to the current plant layout points up tremendous advancement made in plant technology during the intervening years.

growing uses of LPG as motor fuel is that for stationary engines operating irrigation pumps, especially in the southwest, and parts of central western U.S. Perfection of fuel and carburetor systems for this purpose will increase the use of LPG for passenger cars, trucks, tractors, and similar equipment.

Still an unknown quantity but certain of tremendous increases is the use of propane and butane, ethane as well, as raw materials for petrochemicals. Well known is the now "old" hydrocarbon oxidation plant at Bishop, Texas, converting methane-to-butane to a long list of alcohols, aldehydes, acids, ketones, glycols, and many other products, where the greatest problem is the concentration of the different chemicals in the highly complicated mixtures produced.

Additionally, the cracking of these paraffins to olefins as intermediates for all manner of chemicals is progressing apace, with new plants planned, and building at every turn. As of the present we find some petrochemicals in excess supply; some plants (see "New Phase Develops in Petrochemicals" September, 1954, Refining and Petrochemical Edition, page C-7) are producing more than they can sell and the prospects are that some plants must either shut down or curtail runs greatly until the market catches up with production.

This alternate shortage and oversupply is inevitable in some degree in such an industry. The potential market for so many products is so huge that it is incalculable at any given time, even by the leaders of the petrochemical industry or the purveyors of finished product of these innumerable types of products. But as time goes on conditions will work toward a balance. The market will expand as is practically certain in most all commodities and manufacturers will trim their output sails to meet current demands at any given date. Some manufacturers may have hard sledding as production outstrips consumer buying volume, with the inevitable prospect that these "swings" of good and bad market conditions will become less pronounced. A dead level of production just meeting demand means a "planned economy," totalitarianism, and the dead inertia of an industry without incentive or prospect of gainful operations.

For natural gasoline, that is, "pentanes and heavier" which includes potentially more and more butanes, the primary consideration is in the expansion of its all-important motor fuel market. This means largely, in addition to the normal increase in total gasoline consumption from year to year, the inclusion of more butanes in each gallon of motor fuel. In turn this is governed entirely by the fuel systems of the passenger and other gasoline-powered cars and vehicles. Therefore, the natural gasoline industry must give a major degree of attention toward the improvement of these fuel systems so that more butanes can be handled satisfactorily.

These matters have been outlined effectively by Bridgeman and Aldrich, by Legatski and others in recent presentations.* And this can come about by the agressive efforts of only one industry, the automotive industry, aided and abetted in great degree by the petroleum and natural gasoline industries. The sooner a greatly stepped-up effort is made by refiners and natural gasoline companies to induce and to aid the automotive industry to renovate and modernize their fuel systems, the sooner added prosperity comes to all three industries. ★ ★ ★

*Paper before NGAA, April, 1954.

TABLE 1. Typical consumption data on LPG in 25 years.

(Benz-Tucker, *Petroleum Engineer*, January 1954, page E-25)

Year	Sales, in 1000 gal	Domestic and motor fuel	Chemical manufacturing
1929	9,931	5,900	.....
1931	28,770	15,295	.....
1933	.....	16,626	.....
1935	76,855	21,380	.....
1937	141,400	40,823	26,792
1939	223,580	87,530	26,892
1941	462,852	220,722	44,206
1943	675,233	344,962	55,356
1945	1,067,979	533,262	224,291
1947	2,209,797	1,150,538	414,267
1949	2,836,599	1,627,550	544,886
1951	4,227,275	2,456,804	844,507
1953	4,920,000	2,932,000	1,016,000

TABLE 2. Typical natural gasoline production during the last 25 years.

Year	Natural gasoline (1000s of gal)	No. of gasoline plants
1929	2,233,700	....
1930	2,210,000	1035
1931	1,831,900	937
1933	1,412,000	779
1935	1,651,986	830 (approx.)
1937	2,065,434	696
1939	2,169,300	681
1941	2,688,714	....
		(1942) 667
1943	2,773,218	642
1945	4,704,200	606
1947	5,700,400	546
1949	6,597,600	550
1951	8,598,700	525
1953	10,159,400	493.

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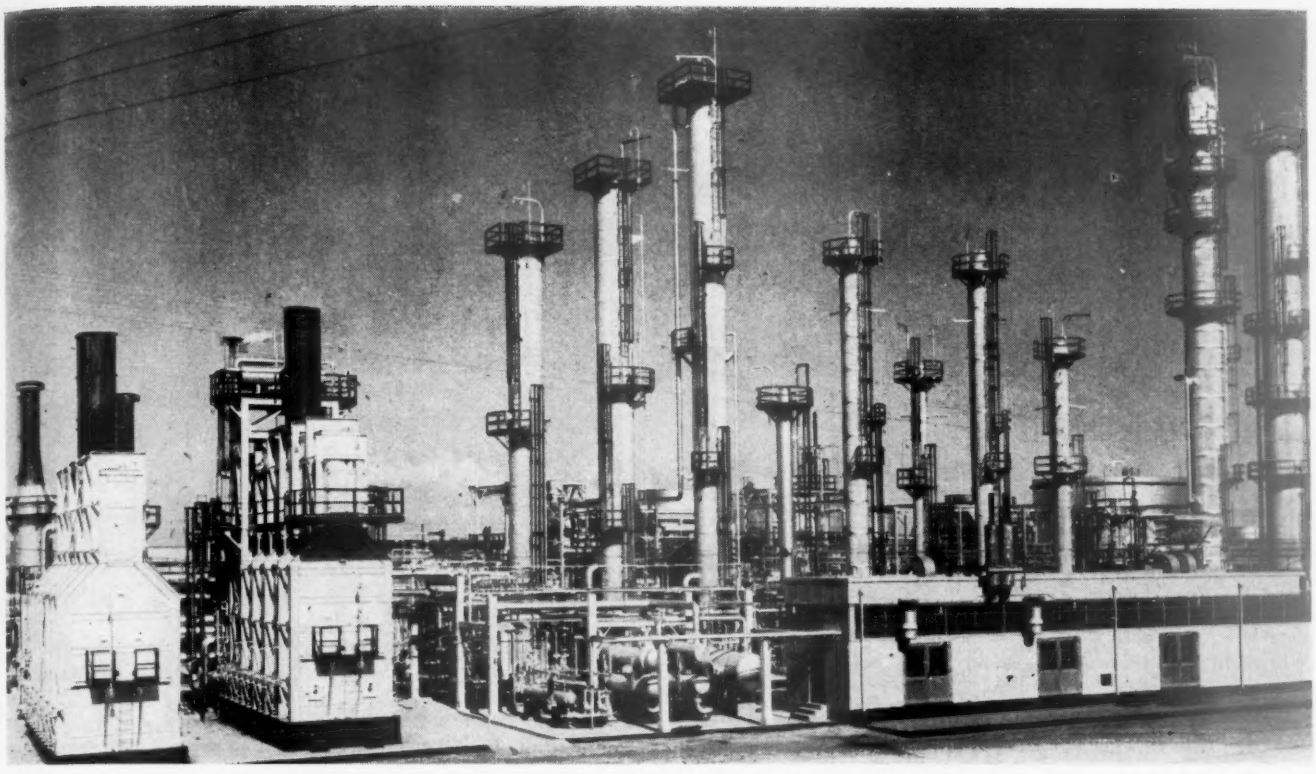


Characteristic of the technical and scientific developments aided by the exclusive use of their developments by inventors is this typical Platformer unit at Cosden's Big Spring, Texas refinery. (UOP license).

New Patent Act Will Improve Patent System

Clarification of what is patentable, contributory infringement and the "Flash of Genius" notion should remove great abuses

VANDERVEER VOORHEES*

A little more than a year ago, on January 1, 1953, the new law codifying the patent practice of the United States went into effect. The new law, variously known as the "Patent Act of 1952," the "Bryson Bill," and "Public Law 593" is a revision of Title 35, U. S. Code relating to patents, and for the first time specifically sets forth many of the practices relating to patents that have grown up through the years, as well as some new ones. The need for the law had been felt for a long time but particularly in recent years when the patent system became a target for those who were opposed to property rights in general and, apparently unable to comprehend the great public benefits arising from the patent system, sought to destroy it piece meal. It is too early yet to observe the effect of the new law on U. S. patent practice, but the trend appears to be favorable.

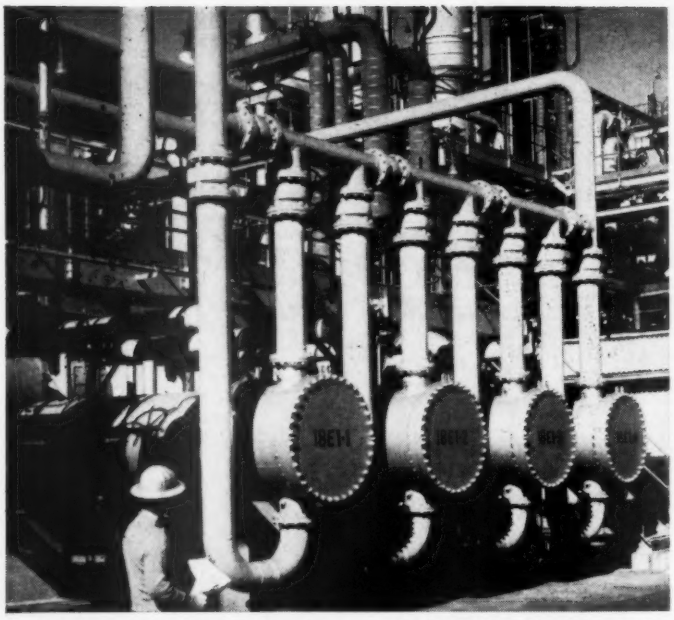
The act is based on the power of Congress under the Constitution to grant patents. For a hundred years, patents were encountered in the United States and many believe that the technical pre-eminence of our country stems from the liberal laws that offered protection to struggling new industries.

Since about 1930, it has become popular for courts to frown on patents, frequently reversing long standing precedents, and the attitude of the Supreme Court has been particularly harsh as exemplified in cases such as the Cuno Engineering case (314-US84) where the automatic cigarette lighter was held to be only another gadget and the more recent A & P case (71-U.S. 127). In the latter case a supermarket checking counter patent was referred to by two justices as another in the "list of incredible patents which the Patent Office has spawned." The fact that Congress passed the new law by unanimous consent indicates a renewed realization of the importance of a strong patent policy for the progress of the nation.

Primary purpose of the new law is to simplify patent procedures and make it easier for an inventor of a worthwhile contribution to the art to obtain a patent that will be respected and enforced in the Courts. There is nothing revolutionary in the new law but there are many features that tend to streamline patent practice. These can be found in the new "Rules of Practice" issued January 1, 1953. (Supt. of Documents,

*Consulting chemical engineer, and patent attorney.

EXCLUSIVE



Acetylene, that almost universal organic "building block" will be purified here in these columns, the whole a tribute to aided and protected research.

Patented processes are employed almost exclusively in this National Petrochemicals plant at Tuscola, Illinois, where synthetic alcohols, acids, ethers, ammonia, etc., are made.

Government Printing Office, Washington, D.C. 40 cents). Following are some of the changes of most interest to the scientist and technologist. Section numbers refer to Title 35, U.S. Code.

Inventors and Assignees

The inventor himself must sign the application for patent just as before, but if he *refuses* or *cannot be located*, a party to whom he agreed in writing to assign the invention may file the application (Rule 47). Likewise, in the case of joint inventors, where one refuses to sign or cannot be located, the others may sign and the patent will be issued to them but it will be subject to the rights of the omitted inventor just as though he had signed. These changes should be very helpful in preventing an uncoperative inventor from tying up the rights of others associated with him in a joint invention.

Where an honest error has been made in the inventorship of an application, it had previously been possible to disclaim one or more inventors in a joint application. Under the new rules, the name of an inventor can also be added where it was omitted by mistake. (Rule 45). This provision should be of real help in cases where the claims finally obtained in the patent are different from those originally sought, and cover subject matter suggested by an associate. A mistake in inventorship of a patent will also not invalidate the patent (Sect. 256) and can even be corrected after the patent is in court in litigation. Thus the new patent act removes many of the pitfalls surrounding the knotty problem of getting the correct names on a patent application coming out of a laboratory where a number of chemists, engineers, and their supervisors are involved.

What is an Invention?

"Invention" means invention or discovery (Sect. 100) "Process" means process, art, or method, and includes a new use of a known process, machine, manufacture, composition of matter, or material. Beyond this, the new act does not attempt to say positively what is patentable, leaving this difficult question right where it was before.

Some have been encouraged to hope that the language "new use of a known — composition of matter" would rescue inventors from the dilemma of having made an important discovery such as the insecticidal property of DDT (dichlordiphenyl trichlorethane), only to find their discovery unpatentable because someone had prepared a few grams of the substance back around 1880 and reported it in Beilstein! The Muller patent on DDT had to be reissued (Re. 22,922) you recall, to direct the claims to DDT *in a solvent*. To force inventors to adopt such a devious method to patent a basic invention seems entirely unjustifiable. The courts who will decide the meaning of the new law now have a good opportunity to correct this situation. Section 102 lists the statutory bars to a patent such as one year public use or publication, etc. Section 103 requires the invention to be not obvious to one skilled in the art "at the time the invention was made." Although this is the same yardstick of invention in use for more than a hundred years, having it clearly stated should relieve inventors of some argument with examiners as to the state of art. This section also provides that the *manner* of making an invention has nothing to do with its patentability. This puts the persistent plodder who sets out to make an improvement, on an equal footing with the prima donna who has a "flash of genius." This is in line with the general tenor of the new law putting the patenting of inventions on an objective basis where it belong rather than a subjective basis where the courts are invited to pry into the private life of the inventor.

Requirements of the Application

Claims must point out the invention and the "means" type of claim is specifically provided for in Sect. 112 which says "an element in a claim for a combination may be expressed as a means or step for performing a specified function without recital of structure . . ." The structure must correspond to that shown in the specification and its equivalents.

Whether this also opens the door to the allowance of "functional" claims is not clear. Many examiners have gone to the ridiculous lengths to reject claims as functional when they merely described procedural steps in the most obvious and straightforward manner, such as "adding sufficient acid to neutralize the base present." To require the inventor to specify the actual weight of acid in such case, neither protects the public nor is necessary to comply with the statute that requires the claim to point out clearly the invention. There is some indication of improvement in this regard already. Thus a recent patent No. 2662,856 claims an oil composition containing a phosphorous com-

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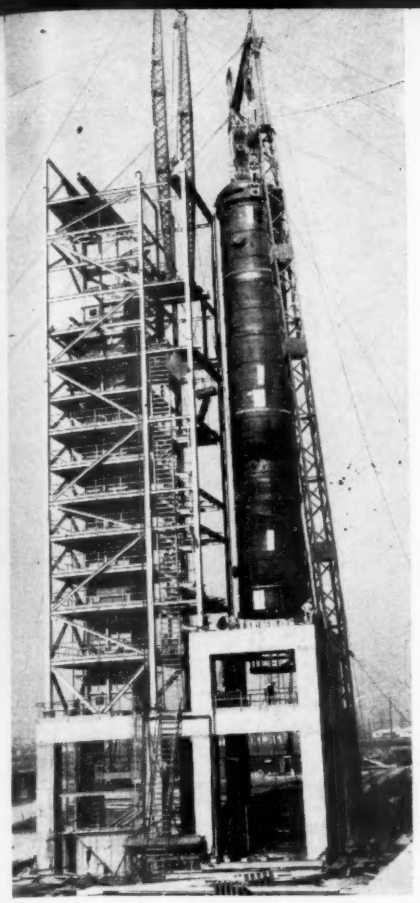

A Thermofor catalytic reformer goes into the refinery of General Petroleum Corporation, Torrance, California, under patents that protect the inventor in his huge investment in research.

pound "— in a small amount sufficient to inhibit deterioration of the oil."

It is no longer necessary for the inventor to sign a divisional application, that is an application having the same specification but claiming only part of the subject matter claimed in the original (Sect. 121). Furthermore, it is now clearly stated that a divisional application cannot be used by the examiner as a reference against the original application or another division, a frequent annoyance in the past.

Five species of an invention can be claimed in one patent but only one of these may omit limitations in the basic or "generic" claim to the invention. If the claims cover "independent and distinct" inventions, "restriction" will be required and a divisional application can be filed to cover the invention divided out. Failure of the Patent Office to require restriction, however, will not affect validity of the patent not so restricted. This places the responsibility of dividing out a separate invention entirely on the Patent Office where it belongs.

Enforcing the Patent

Section 282 clearly states that a patent will be presumed valid, thus placing the burden of proof on any infringer who contends it is not. This should have the effect of dignifying a

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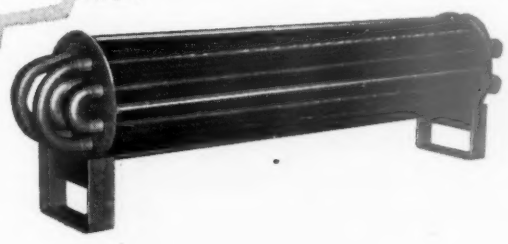

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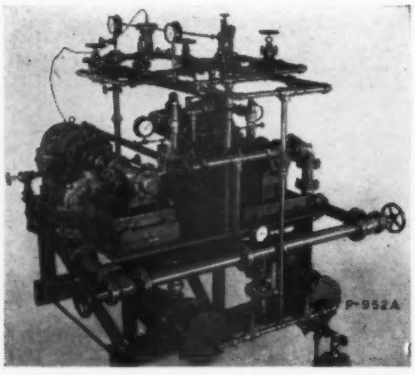

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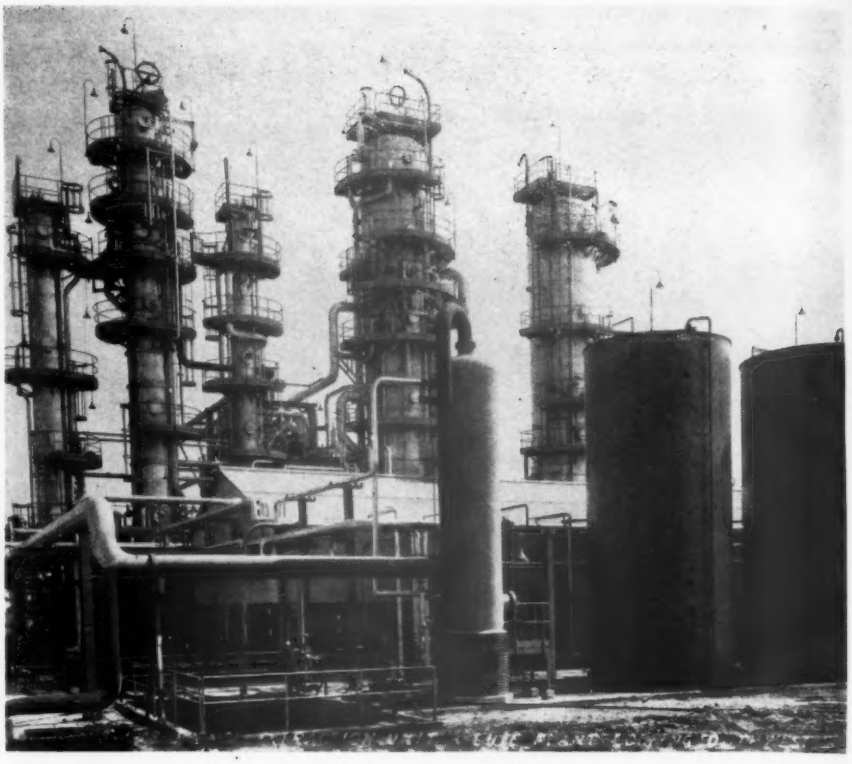

Purification and refining of lubricating oils has been upgraded from an art to a science, as indicated by the processes employed in this Phillips Petroleum Company lube plant at Kansas City, Kansas.

patent and educating some of the courts where patent cases are infrequent. It has always been the law, but in recent years, some judges seem not to have heard of it.

Section 154 properly states that a patent gives the right to *exclude others* from making, using, or selling the product of the invention. Previously the patent right was stated to be the "exclusive right to make, use and vend" the product of the invention, an inaccurate statement where the patent was dominated by another.

Previously there was a severe penalty imposed by the courts in cases where infringement suits were brought on patents containing one or more invalid claims and it was necessary to disclaim such claims "within a reasonable time" to save the patent. Under the new law (Sect. 288) if such invalid claims are not disclaimed before the suit is started, the patentee can not recover costs of the suit, but otherwise the action can proceed on the valid claims without penalty.

Contributory Infringers are Liable

Contributing to the infringement of patents, although not definitely infringing, is now recognized as illegal in the new law which says, in Section 271, "whoever actively induces infringement of a patent shall be liable as an infringer." We now have, for the first time, a realistic approach to this knotty problem which has existed for a long time, at least as far back as the famous "Victrola case" where (213 US 325) 1909 the patent covered the machine and record as a unit. Sale of additional records by another manufacturer was held to be an infringement of the patent.

The practice of holding liable as infringers, those who only encourage it, has grown up in the courts to solve such problems. Some have feared that the courts went too far in some cases, giving the patentee an unwarranted monopoly on the sale of materials in common use, just because they were used in his invention, and a reversal set in some years ago with a chain of decisions extending from the "dry ice package case (283 US 27) through the "Barber asphalt concrete coating case" (302 US 458) to the Mercoid electric controller case." (302 US 661) The tenor of these decisions was that it was not legal to tie the sale of a common commodity like dry ice or asphalt to a patented package, composition or process. As a result of these decisions, there was some question whether anything at all had been left to the doctrine of contributory infringement. Now a reasonable answer

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PROCESS EQUIPMENT NEWS

PUBLISHED BY FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY — OCTOBER-NOVEMBER 1954

Interchangeable Bundles for Three Condenser Units

Three condensers recently completed in the Kellogg shops for a major refiner represent an optimum interchangeability of bundles—a feature every refiner wants but one that is often difficult to achieve in a unit without over-engineering it.

The three condenser units, designed to handle C-4 cuts, comprise a total of 14 shells. Following normal design practices, initial Kellogg engineering proposals included three sizes of shells. However, further study by Kellogg engineers proved, in this instance, that it would be most economical in the long run to design the entire group of 14 shells for interchangeable bundles. Both proposals were submitted, the customer agreeing that the interchangeable bundle plan best served their purposes.

Each of the 14 sections are of floating tube sheet construction with 2040 square feet of ¾-inch admiralty tubes, naval brass tube sheets, and steel baffles. Inside diameter of each shell is 33 inches.

Interchangeable bundles for this many sections will offer several important advantages to the refiner. They will, for example, cut down considerably on refinery maintenance stock, since only one spare bundle need be kept in stock to service any one of the 14 sections. Shorter down-time for repairs are also expected to result from the fact that the spare bundle can be substituted easily in an emergency without shutting the unit down for lengthy repairs or rebuilding.

For further information, details of methods, etc. contact

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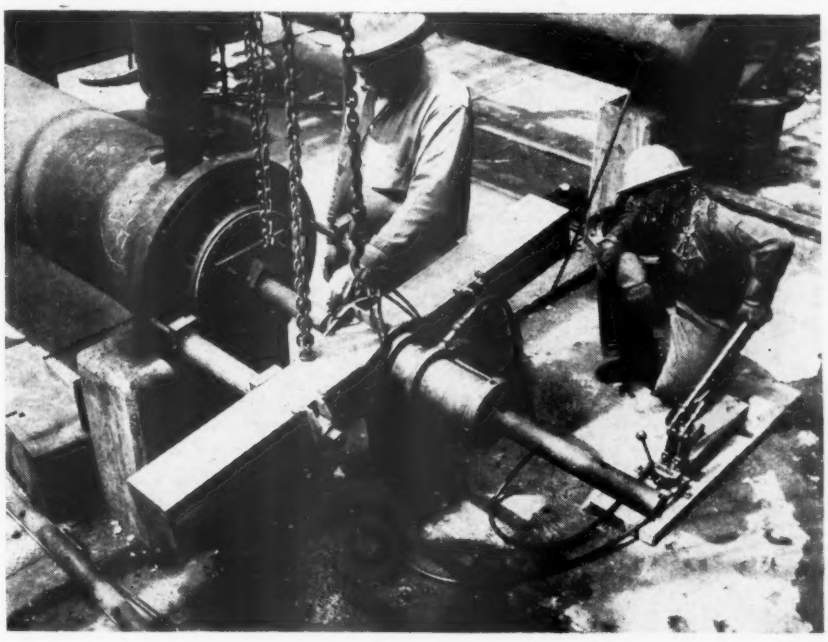


Portable Bundle Puller Saves Time Eliminates Costly Rigging

Shown here in use at a major Eastern refinery is Kellogg's special device, known as the Hydro-ejector, for removing and inserting heat exchanger bundles.

The device, portable and easily operated by two men, reduces down-time and eliminates the need for "jerry-built" rigging often required to pull even the smallest tube bundles. From the standpoint of time, experience has shown that it takes less than 25 minutes for the device to push a tube bundle out eight feet.

And even the largest bundles will not stick when pushed by the force of 12,000 pounds that may be exerted by the Hydro-ejector. The device is attached directly to the bonnet-end shell flange of the exchanger. It does not pull a bundle; it pushes it.

The Hydro-ejector is safer to use—particularly in the case of overhead exchangers—because workmen do not have to clamber out on the bundle after it is partly pulled to attach hoists. Ropes for lowering the bundle are attached as it is ejected and ride along with the unit from a trolley on the hoisting beam.

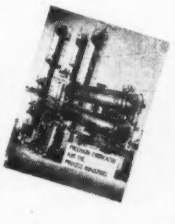
The Hydro-ejector will fit any size exchanger. Although now available for use in existing refineries, the unit was originally designed for customary types of exchangers in new processing plants as a means of reducing investment for supporting steel work. In cases where more than one Hydro-ejector is used, all parts including the jack and pumping unit are interchangeable. The only auxiliary equipment are two hoists, suspended at the channel end of the exchanger, to handle the tube bundle as it is ejected or replaced.

In operation, two men may work it with ease. One is required to pump the jack while the other keeps an eye on the bundle to ensure alignment.

Each unit consists of a hydraulic center-hole jack, supported by a fabricated steel base which is bolted directly to the exchanger. It is self-contained and portable, the heaviest piece of equipment being less than 75 pounds.

Send for New Booklet On Kellogg Exchangers

A new booklet which describes in detail the types of tubular heat transfer equipment available from Kellogg has just been completed. It not only shows examples of a variety of heat exchangers, coolers, condensers, reboilers and other process equipment, but also covers in some detail the expanded facilities available at Kellogg since the shops were modified for production-line manufacture of heat transfer units.



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has been supplied to this question by the new patent law, which says that a contributory infringer is one who sells a component of a patented machine or composition or sells apparatus or material for a patented process, knowing it to be especially adapted for infringing the patent and not a "staple article or commodity of commerce suitable for substantial non-infringing use." It will be interesting to see how the courts apply this yardstick to actual cases of contributory infringement.

The new law goes one step further in providing that the patentee may attempt to enforce his patent against contributory infringers without being considered to have misused or illegally extended his patent right.

Marking the Article

Patented articles should be marked "pat." or "patent" together with the number of the patent or when this cannot be done, the package should be so labeled. "In the event of failure so to mark, no damages shall be recovered by the patentee in any infringement action except on proof that the infringer was notified of the infringement and continued to infringe thereafter, in which event, damages may be recovered only for infringement occurring after such notice." (Sect. 287) Damages cannot be recovered for infringement committeed more than six years before filing suit. (Sect. 286). The penalty for falsely marking an article "Patented" when it is not, has been changed from $100 minimum to $500 maximum.

Reissue of Patents

Where a mistake has been made in a patent, for example where the claims are too narrow or too broad, it can be reissued by surrendering the patent and paying the necessary fees. (Sect. 251) This can be done at any time during the life of the patent except where the claims are broadened in which case it must be done within two years of the date of issuing the original patent. Reissued patents expire on the same date as the original patent, so that no extension of the patent monopoly can be gained by this means.

Where the reissued patent has broader claims than the original, it cannot be asserted against an infringer who would not have infringed the original patent and who made, used, or sold the product or carried out the process before the date of the reissue patent, or even if he only made preparations to do so. Accordingly, the public, acting in good faith after the issue of a patent and avoiding the claims while manufacturing a similar item, is protected in this activity and investment against an expansion of the patent monopoly by reissue. Thus, the O'dell patent, 1,984,380 on fluidized carbonization issued in 1934 was reissued in 1940 as Re: 21,526 with claims slanted toward cracking oil with fluidized catalyst. Under the new law, the reissued patent would not have been infringed by those who became engaged in using the process in the intervening six years. This only applies, of course, to similar situations arising after January 1, 1953, not before.

Section 251 also provides that more than one patent can be obtained by reissue, that is, the original patent can be divided into two or more reissues. The assignee of the entire interest in a patent can reissue it without consulting the inventor in case the claims are not broadened.

Appeals

Little change has been made in respect to appeals. Appeals from the Patent Office to the District Court of the District of Columbia are provided for in Section 145 to 146 which replace the old law, R.S. 4915. In interference cases, a patentee can now appeal to the District Court, whereas previously he was limited to the Court of Customs and Patent Appeals, only applicants for patents being permitted to go the civil court route.

Appeals within the Patent Office from an examining division to the Board of Appeals now require a twenty-five dollar fee instead of fifteen as formerly.

Secrecy Provisions

The secrecy during the second World War that surrounded the atom bomb project naturally penetrated the Patent Office and the rules then adopted have been incorporated in the new patent act. Section 181 of the act provides that any invention whose publication would "be detrimental to the national security" in the opinion of the Commissioner of Patents, must be submitted to the Atomic Energy Commission and to other defense departments. If one of them decides the invention must be kept secret, no patent may issue on it until such order is rescinded. The applicant for any patent must wait six months before filing in a foreign country, (Sect. 184) to allow time for a secrecy order to issue, if any, but he may file abroad sooner with permission of the Commissioner of Patents. Unauthorized disclosure of inventions under secrecy order may result in abandonment of the patent application. Right of compensation for delay caused by the secrecy order, or use of the invention by the Government, will be determined by the courts, providing the agency that issued the secrecy order is unable to conclude a settlement satisfactory to the inventor. (Sect. 183)

Decisions of the Courts

It is still too early to say whether the new statute has had the effect of making patents easier to get and sustain. In three recent decisions of the Court of Customs and Patent Appeals, in which the new law was referred to, two were decided in favor of the inventors and one against. In the case of Harding, 676 OG 907, an architectural structure was held obvious to a person "having ordinary skill in the art" and the application was rejected. In O'Keefe — 672 OG 895, a heat deflector in a stove that functioned differently was considered patentable, the Court reciting in support of its decision "Patentability shall not be negatived by the manner in which the invention was made."

In Tanczyn, 672 OG 7 claims to a wrought and polished stainless steel, low in maganese and silicon, were held patentable over references showing stainless steel equally low in these elements but failing to show it was wrought and polished, the invention residing in elimination of splotches caused by surface inclusions on polished surfaces.

Summary

Reporting on the new law the author concludes: "The new patent act is a brave attempt to relieve inventors of the annoyances and injustices to which they have been subjected in recent years, to the detriment of the patent system as a whole, and to the retarding of technical progress which patents are intended to promote. It is now up to the Patent Office and the courts to do their part to restore the patent system to its rightful place in our economy. It is still too early to see how they are meeting the challenge." ★ ★

New Chemical

Stauffer Chemical Company has recently increased its production facilities to offer commercial quantities of PerchloroMethyl Mercaptan (PMM). This reactive intermediate has a list of potential uses in such products as lubricants and fuel additives, biocides, rubber additives, dyes or dye intermediates.

Primary chemical activity of PerchloroMethyl Mercaptan (PMM) centers about the reactive sulfur-linked chlorine atom. As a result, PerchloroMethyl Mercaptan (PMM) will react with amides, imides, olefins, thiols, xanthates, sodium alkoxides, and all amines. Substituted guanidines are also obtainable. A technical bulletin describing the properties and reactions of this interesting sulfur-chlorine aliphatic is available.

Plants producing PerchloroMethyl Mercaptan (PMM) are at Richmond, California and Perry, Ohio.

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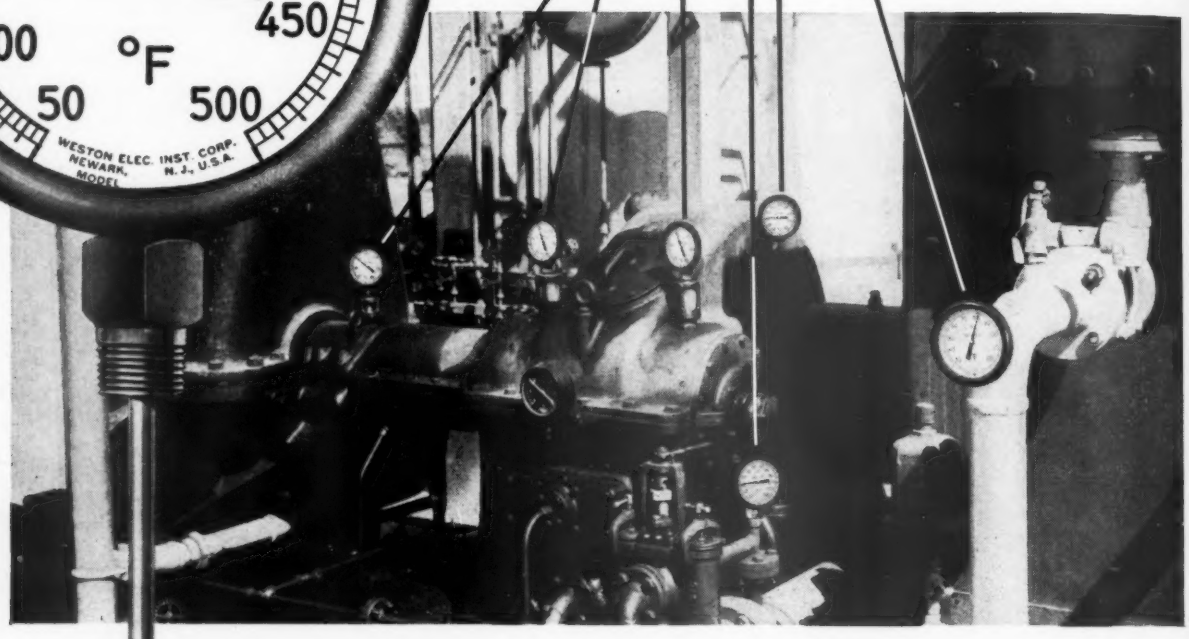
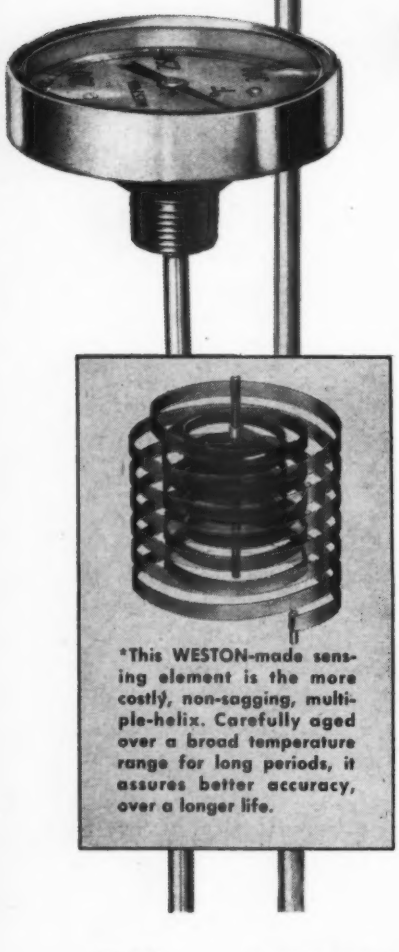
AT EVERY CHECKPOINT





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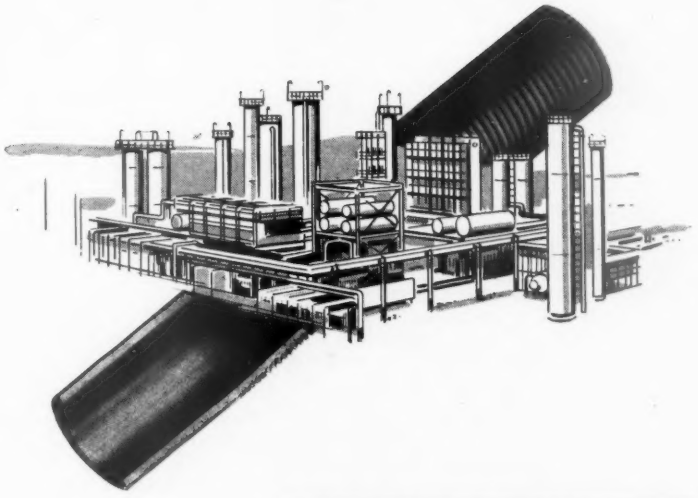

Look at the chart in the next column. It graphically compares two condensers identical in size used for condensing Freon 12 with water. One condenser is tubed with prime surface tube, the other with Wolverine Trufin, Type S/T. BTU's per hour soar from 390,000 to 575,000—an increase of 47%!

• • • •

This is proof positive of the economies awaiting those engineers who insist on Trufin for shell and tube heat exchangers. Not only do you boost capacity—get more BTU's per foot of tube—but you get more "in line" service as well. Because the fins of Trufin are integral—extruded from the tube wall—they can't shake loose as a result of vibration, pressures, or temperature changes.

Unusual? No! This is just another example of the type of service given every day by Trufin. While this is a specific application, the same benefits apply to other types of hydrocarbon condensers. It could be in any refinery or petro-chemical plant—maybe yours!

Trufin is available in copper (and its alloys), aluminum, electric-welded steel, and bimetal. You can get similar case histories—more pertinent data—if you write for Wolverine's new "Opportunity" Booklet. It's yours for the asking!

*REG. U.S. PATENT OFFICE

Wolverine Trufin available in Canada through the Unifin Tube Company, London, Ontario.

	PLAIN TUBE	TRUFIN TYPE S/T
Shell Size, O.D.	12¾"	12"
Tube Length	7'	7'
Tube Specification	⅝" OD—18BWG 90-10 Cu. Ni.	⅝" OD—18BWG 90-10 Cu. Ni. Trufin Type S/T
Outside Surface Sq. Ft.	143.34	334.0
No. of Tube Passes	4	2
On the basis equivalent water flow Water Flow USGPM	102.0	107.2
Water Velocity, FPS	4.68	3.32
Heat Load BTU/ (Hr.)	411,000	652,000
U_d, BTU/(Hr.) (°F) (Sq. Ft.)	186.3	155.2
U_l, BTU/(Hr.) (°F) (Lineal Ft.)	30.6	63.0
On the basis equivalent water velocity Water Flow, USGPM	102.0	152.5
Water Velocity, FPS	4.68	4.72
Heat Load, BTU/(Hr.)	411,000	829,000
U_d, BTU/(Hr.) (°F) (Sq. Ft.)	186.3	180.2
U_l, BTU/(Hr.) (°F) (Lineal Ft.)	30.6	73.0
Calculated heat Loads with a fouling factor of 0.0005	390,000	575,000

From the data, the advantage of TRUFIN can be clearly seen either on an equivalent water consumption basis or an equivalent water velocity basis.

Although this data was obtained on a clean tube basis, we have shown calculated values on the basis of a fouling factor of 0.0005 (considered to be standard for this service.)

WOLVERINE TUBE, Division of Calumet & Hecla, Inc., 1439 Central Avenue, Detroit 9, Michigan.

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REFINERY PLANTS SCHEDULED FOR COMPLETION

Pan-Am Southern Corporation. Only 147 days after beginning construction, Pan-Am put on stream a 730 bbl per day Ultraformer unit, using a platinum-based catalyst in a fixed-bed system with regeneration provisions. The Lummus Company received a 46-day bonus for completing the plant ahead of time.

★ ★ ★

Sun Oil Company. A 27,000 bbl per-day Houdriflow catalytic cracker unit is to be built by Sun at its Toledo, Ohio, refinery with Catalytic Construction Company as constructor. Houdry Process Company and Sun Oil are doing the engineering. Unit replaces the Houdry fixed-bed units, which were pioneer large-scale cat cracking units.

★ ★ ★

Rock Island Refining Corporation. A 2400 bbl per day platformer, distinctive in being the first refining unit controlled entirely by electronic instruments, started operation in late July at company's Indianapolis plant. The new control system eliminates tubing racks and is expected to reduce maintenance problems found in conventional instrument systems. Unit was built by refinery staff in about a year.

★ ★ ★

Columbia Southern Chemical Company. A $3,000,000 ammonia synthesis plant at Natrium, West Virginia, is to be built by Chemical Construction Company. Columbia Southern is a subsidiary of Pittsburgh Plate Glass Company.

★ ★ ★

Standard-Vacuum Oil Company (India). This new 25,000 bbl per day Bombay refinery is now on stream 6 months ahead of schedule. Cost of plant is $32,000,000; capacity, 300,000,000 Imperial gal per year of products. Bombay plant will supply one-third of all India's petroleum products needs. This is second of 3 eastern hemisphere refineries for Standard-Vacuum that when completed will have a total of 82,000 bbl per day capacity. One plant is at Durban, South Africa; other is the Melbourne, Australia plant, which is to be enlarged to 25,000 bbl per day capacity. It is to be completed in 1955.

★ ★ ★

Refinaria E E. De Petroleo Uniao, S. A. The largest airlift TCC unit in the world will be completed soon at Sao Paola, Brazil, at the Capuava plant, by Hydrocarbon Research, Incorporated, contractor-engineering company of New York. Unit will have 25,000 bbl per day crude capacity and the first moving-bed cracker in South America.

★ ★ ★

Chinese Petroleum Corporation (Taiwan). A Socony (TCC) Type-45 cracking unit of 6500 bbl per day charge capacity, including feed preparation and gas recovery auxiliaries is planned for Kaohsiung refinery on Formosa. Unit is to be completed by mid-1955 by Fluor Corporation.

Brea Chemicals, Inc. Beginning of construction on a new ammonium phosphate plant at Brea, California, to provide western growers with another important plant food in easy-to-handle solution form, has been announced by Homer Reed, president of Brea, subsidiary of the Union Oil Company of California. Plant will be constructed by Macco Corporation and is scheduled for completion the latter part of September. Company expects to have 2 similar plants in operation at Brawley and Fresno, California, early next year.

★ ★ ★

Sunray Oil Corporation. A new 9000 bbl per day delayed coking unit went on stream at Sunray's Duncan, Oklahoma, refinery recently, to make cat cracker stock and petroleum coke. Mississippi River Products Line, Incorporated, line to a river head near Memphis, Tennessee, and a 5000 bbl per day platformer unit were completed at the same time. Coker belongs to Ucan Products Company, of which 50 per cent is Sunray. Unit will make 360 tons per day or 120,000 tons per year of coke, to go to Great Lakes Carbon Company for distribution. Olefins and light hydrocarbons will be recovered also.

★ ★ ★

Girdler Corporation-du Pont Company. Plants for making nitric acid via the du Pont process will be built by Girdler Corporation of Louisville, Kentucky. This process has been improved greatly in recent years, since Girdler built the first one in 1949.

Girdler also engineered a 40-ton-per-day sulfur recovery unit at the Aruba, N. W. I. plant of Lago Oil and Transport Company, Ltd., Standard of New Jersey subsidiary. Unit was built by M. W. Kellogg Company, and uses ethanolamines to concentrate the hydrogen sulfide from plant waste gases, which is then reduced to elemental sulfur in another unit.

★ ★ ★

Standard Oil Company (California). Standard's $20 million, 40,000 bbl per day fluid catalytic cracking unit is on stream at El Segundo refinery. A unit for converting hydrogen sulfide from the plant gases to sulfuric acid, to be used in refining operations, is also in operation. A 52,000 bbl per day residuum stripper for cat cracker feed preparation from refinery residual fractions is included in the new project.

★ ★ ★

Carbide and Carbon Chemicals Corporation. A new plant for manufacture of alcohols, aldehydes, acids, etc., via the Oxo process, is to be completed soon at Texas City. Seven new Oxo chemicals are being made in pilot plant quantities at C and C's Charleston, West Virginia, plant, including primary decyl, tridecyl alcohols, and iso-octyl alcohol. Reaction is between an olefin, such as ethylene, propylene, etc., and carbon monoxide and hydrogen, making aldehyde with one more carbon atom in the molecule than is in the olefin used. Pressures of up to 6000 psig, and temperatures of 392 F are employed. Alcohols named are used or may be developed into plasticizers, surface-active agents, etc.

Cosden Petroleum Corporation. A 2065 bbl per day HF alkylation unit, built by Universal Oil Products Company, went on stream in August at Cosden's Big Spring refinery. Unit produces 115-145 octane rating aviation fuel, by blending alkylate with isopentane, and with toluene obtained from the nearby platformer-udex unit Cosden operates. Alkylation unit is distinctive in having a horizontal contractor, instead of the vertical contractors of wartime design. Unit charges propylene, butylenes amylenes in contact with isobutane, all made in a fluid catalytic cracker in the refinery.

★ ★ ★

Commonwealth Oil Refining Company. A 26,800 bbl Houdriflow unit and a 3730 bbl Houdriformer unit will be built at Guayanilla Bay, 15 miles west of Ponce, Puerto Rico. These are the 99th and 100th Houdry units to be licensed, and the largest Houdriflow unit outside continental U. S. A. The completed refinery with a nominal capacity of 23,000 bbl per day, will operate largely on Middle East and Venezuela crudes.

★ ★ ★

Standard Oil (Indiana). A new Ultraforming unit of 14,000 bbl per day capacity is scheduled for the Sugar Creek, Missouri, refinery, says H. R. Boehmer, manager. Ralph M. Parsons Company will build the unit, to be on stream in early fall of 1955. Ultraformer units are being built at Pan American Refining Corporation, Texas City, Texas, plant and at Indiana refineries in Wood River, Illinois, and Casper, Wyoming. Two others are being planned, for Canadian Petrofina near Montreal, Canada, and Great Northern Oil Company at St. Paul, Minnesota.

★ ★ ★

Quaker State Oil Refining Company. A 1500 bbl per day platformer, the first of 3 such units for the company, went on stream recently at its Farmer's Valley plant near Bradford, Pennsylvania. Other units being built by Procon, Incorporated, are at the St. Mary's, West Virginia, and Emlenton, Pennsylvania, refineries. They are expected to start operations this fall.

★ ★ ★

Ohio Oil Company. An 8330 bbl Houdiformer has been completed at the Robinson, Illinois, refinery and placed on stream. Unit was built by Catalytic Construction Company and has 3 main reactors, a guard reactor, and a 3-stage direct-fired heater.

★ ★ ★

Aurora Gasoline Company. The first licensed Fluid Coker unit will be built at Aurora's plant in Detroit soon, and the company will market a new type of coke fuel in the marketing area. Production is being rated at 100 tons daily. A 7500 bbl per day Unifiner will be built also, and will use excess hydrogen from the platformer unit to desulfurize motor fuels, etc. Hydrogen sulfide will be extracted by ethanolamine solution, from which free sulfur will be produced, about 30 tons daily. Ralph M. Parsons and Procon, Inc., will do the construction.

REFINING AND PETROCHEMICAL PERSONALS

Elster A. Smith has been appointed to the newly created post of assistant manager of the gas supply department of Lone Star Gas Company and its wholly owned subsidiary, Lone Star Producing Company.

Smith, a graduate of Southern Methodist Universary, joined Lone Star in 1929 as a meter inspector in the field for the gas measurement department. Smith to assistant process superintendent. was an engineer in the newly created gas supply department of the exploration and gas supply division at the time of his appointment.

H. J. Bemis, manager of the gasoline and refined oils department of Standard Oil Company (Indiana), has retired. **H. K. Apel,** assistant manager of the department, has been promoted to succeed him as manager.

Bemis joined the company in 1911 at Chicago, Illinois. He was promoted to assistant manager at St. Louis, Missouri, in 1922, and was transferred to the same position at Milwaukee, Wisconsin, later the same year. After becoming an assistant general manager at Chicago in 1939, Bemis was appointed manager of the gasoline and refined oils department in 1943.

Apel joined Standard in 1914 as a clerk and stenographer. After serving as an aviation sales promoter, sales manager of naphthas and gasolines, and in other positions of increasing responsibility, he became assistant manager of the gasoline and refined oils department in 1948.

W. B. Burgess, gas plant superintendent of Humble Oil and Refining Company's Kilgore, Texas, gas plant, has been transferred to the Heyser, Texas, gas plant as plant superintendent.

Edward F. Morrill has been appointed general manager of the new petrochemical division of Standard Oil of Ohio. Morrill was formerly president of Mid-Valley Pipe Line Company. He will be responsible for the construction of Sohio's $17,000,000 manufacturing plant to be built in the Toledo-Lima area.

R. N. Reed, fire department head at the Esso Standard Oil Company refinery in Baton Rouge, Louisiana, was one of the 24 representatives of United States and Canadian industrial firms attending the three day fire school conducted by Ansul Chemical Company, Marinette, Wisconsin, August 23-25. Purpose of the school is to train industrial fire marshals and safety engineers in the latest techniques of extinguishing difficult fires with dry chemicals and other equipment.

Reed is responsible for the training program of a 28-man fire brigade at the refinery.

L. J. Brewer, former assistant manager of the Esso Belot refinery in Cuba, has been named president of Esso Standard Oil, S.A. Havana, Cuba. He succeeds **Fred H. Billups,** who has been named president of the newly formed Tropical Gas Company.

Arlie A. O'Kelly has been appointed director of research for Pan American Refining Corporation. **Preston L. Brandt** has been named coordinator of research.

John M. Campbell, former manager of the processing equipment department of Black, Sivalls and Bryson, Oklahoma City, Oklahoma, has joined the staff of the School of Petroleum Engineering, University of Oklahoma, at Norman, Oklahoma. Campbell also will operate a consulting service from P.O. Box 2218, Norman, in the oil and gas production field, specializing in, among other divisions, process and economic evaluation work. He is well known to the industry, especially for his work in dehydration of gases and vapors, and other phases of the industry's activities.

O. N. Miller has been appointed a vice president of Standard Oil Company of California.

Miller, who has been general manager of Standard's manufacturing department for the past eight years, came to work for the company in 1934. His experience includes both the research and refining fields, including planning and design of the Ras Tanura Refinery in Saudi, Arabia. Miller is a graduate of the University of Michigan.

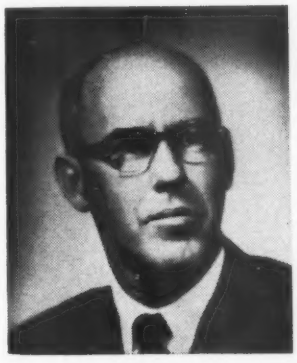
Thell C. Woods, formerly process superintendent of Deep Rock Oil Corporation's Cushing refinery, has been promoted to assistant to the vice president. **Raymond Feasel** will become process superintendent replacing Woods. Feasel was formerly fuels manufacture supervisor.

Quentin E. Benedict was promoted from lubricants manufacturing supervisor to be assistant process superintendent. **Thomas Coleman Jones,** formerly shift supervisor, has been promoted to cracking plant foreman.

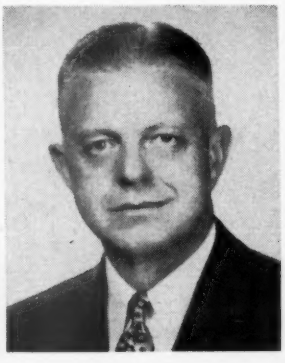
Woods is an 18-year veteran with Deep Rock. He received his BS degree in chemical engineering in 1934 from the College of the Ozarks. Before joining Deep Rock he was a high school principal for several years. Feasel joined Deep Rock in 1949 as cracking supervisor and was promoted 3 years later to fuels manufacture supervisor. He attended public schools in Oklahoma and the Arkansas City, Kansas, Junior College.

Benedict came to Deep Rock in 1949 as treating and distillation supervisor and was promoted in 1952 to lubricants manufacturing supervisor. He received his BS degree in chemical engineering from the University of Cincinnati and was employed as a chemical engineer for another oil company before joining Deep Rock.

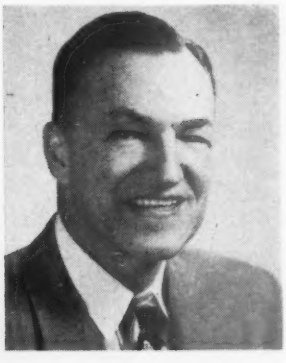
Jones is a 31-year veteran with the company. He has held a number of positions with the company leading to his current promotion.



L. B. Dorsey



H. G. Vesper



A. L. Lyman

Leon B. Dorsey, former plant superintendent at Southern Production's Pledger gasoline plant near West Columbia, Texas, been transferred to the general offices of the company in Fort Worth, Texas. Dorsey has been appointed superintendent of gasoline plants and assigned the duties of coordinating all gasoline plant activity for the company. **M. V. Dunk,** assistant superintendent, will replace Dorsey at Pledger.

Dr. Donald L. Benedict has been appointed director of physical sciences research for Stanford Research Institute. He was formerly assistant director of the engineering division. With SRI since 1949, Dr. Benedict has supervised programs in electronics research and has participated in theoretical and technical work in the application of new materials to electronic components. He has been a consultant to Raytheon Manufacturing Company.

Daniel L. Hussey, general superintendent of Esso Standard Oil Company's refinery at Bayway, New Jersey, has been loaned to the Abadan refinery, Iran, as head of a refinery survey party. **G. R. Murrell,** head of the petroleum products division at the Baton Rouge, Louisiana, refinery, was named to replace Hussey.

H. G. Vesper has been assigned to direct marketing, supply, and transportation for Standard Oil Company of California in the western area. Vesper, a vice president of Standard since 1952, has been president of California Research Corporation for the last eight years.

A. L. Lyman has been elected president of Cal Research to replace Vesper. Lyman joined Standard in 1924, following graduation from the University of California. He was named executive vice president of Cal Research in 1953.

Dr. J. W. Bertetti, general manager of manufacturing, has been elected to the board of directors of Pan-Am Southern Corporation. He succeeds **M. C. Hoffman,** formerly vice president in charge of exploration and production for Pan-Am. Hoffman transferred to an executive post with Stanolind Oil and Gas Company, the exploration and production subsidiary of Standard Oil Company (Indiana).

Bertetti received his undergraduate training at the University of Illinois and was awarded his master's and doctor's degrees in chemical engineering from the University of Michigan. He joined Standard Oil Company (Indiana) in 1934 as a member of that company's research staff at its Whiting, Indiana, refinery.

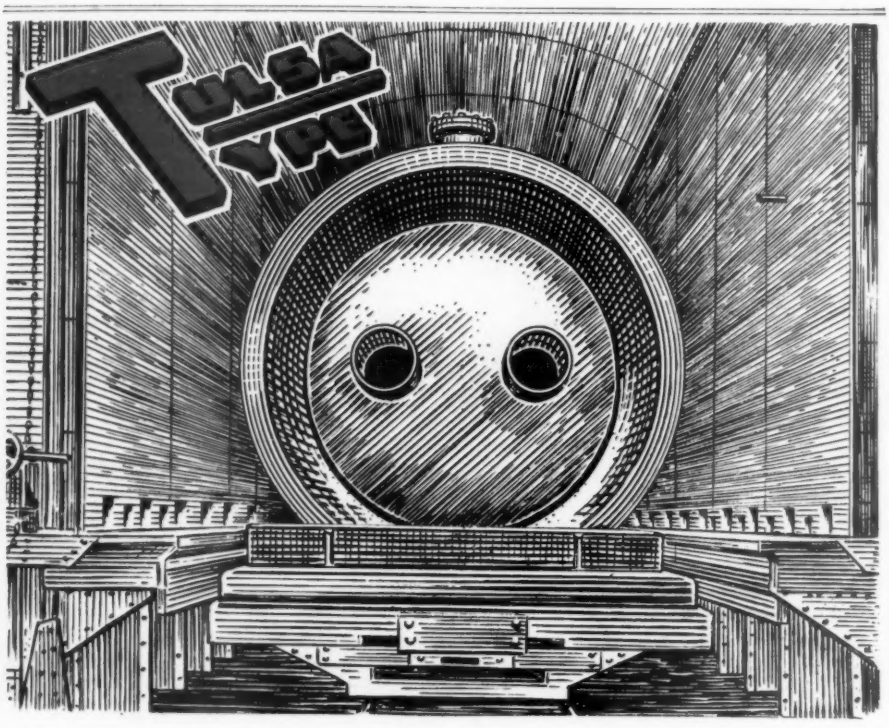
XUM

Personals

▸ **G. W. Watts** has been named director of engineering and engineering research of Standard Oil of Indiana. **F. W. Scheineman,** chief engineer of manufacturing since 1951, was appointed manager of the general engineering department. **G. M. Keranen** was named the general engineering department's assistant manager for the construction, co-ordination, and contracts. **W. G. Guild** was appointed assistant manager for design engineering. **C. E. Evans,** superintendent of the projects division at the Whiting refinery, was appointed the new department's assistant manager for project engineering. **P. L. Krauel** is chief of engineering division.

Watts joined Standard as a draftsman at Whiting in 1915. Except for a leave of absence during World War II to serve as consulting engineer on the Oak Ridge, Tennessee uranium diffusion plant, he has been with Standard ever since. Scheineman joined the company in 1926 as an engineer at Whiting. There he rose to a group leader and assistant chief engineer. He was transferred to the general office in 1943, where he served as assistant chief engineer.

Keranen became a designer engineer at Standard's Whiting refinery in 1927 and advanced to assistant chief engineer in 1942. Guild joined Standard in 1930 and rose to assistant chief engineer of the Whiting refinery. Evans joined Standard in 1937 as a chemical engineer in the research department at Whiting. He was transferred in 1942 to the refinery, where he became general foreman of the pressure stills department in 1946, assistant superintendent of the light oils division in 1948, and superintendent in 1949.



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H. S. McCray

▸ **Howard S. McCray** has been appointed manager of operations of the Texas Company's refining department. McCray was formerly superintendent of Texaco's refinery at Lockport, Illinois.

Eddins W. McNealy, former superintendent at Eagle Point, Westville, New Jersey, was named superintendent at Lockport. **Robert H. Aitken,** former assistant superintendent at Eagle Point, was appointed superintendent of the refinery. **Horace H. Chandler,** former assistant superintendent of manufacturing at the Port Arthur, Texas, refinery, was named assistant superintendent at Eagle Point.

McCray, a graduate of Pennsylvania State College, joined The Texas Company in 1926 as an engineer at the Port Arthur, Texas refinery. In 1940 he was appointed superintendent of Texaco's Sunburst, Montana refinery. He was later named superintendent of the Lockport refinery in 1950.

McNealy graduated from Rice Institute in Houston, Texas, with a BS in chemistry in 1932 and then joined the company as a chemist at the Beacon, New York, laboratories. He became assistant superintendent of the company's Casper, Wyoming, refinery in 1949. McNealy had been superintendent at Eagle Point since 1954.

Aitken began with Texaco as a draftsman in 1926 after graduating from Rose Polytechnic Institute in Terre Haute, Indiana, with a BS in mechanical engineering. He was appointed assistant superintendent of the San Antonio refinery in 1942. Aitken was named assistant superintendent at Eagle Point in 1954. Chandler joined The Texas Company in 1932 after completing his BS in mechanical engineering at Cornell University. He was named assistant to superintendent at Port Arthur in 1943, supervisor of light oil processing in 1947, and assistant superintendent of the refinery in 1953.

E. L. Droddy has been appointed assistant to general manager in New York. **W. R. Sorenson** and **R. E. Manley** have been named assistant supervisors of the process division. **T. R. Moore** was appointed assistant supervisor of the cost and statistical division, and **C. J. Cohlin** was named supervisor of the salary administration and employee plans division.

In Port Arthur, Texas, **C. E. Lauer** was appointed superintendent of product control. **Charles Richker** was named chief process engineer and **W. M. Abbey,** chief chemist.

▸ **Dr. Per K. Frolich** has been made deputy to the chief chemical officer and chief scientist for the Chemical Corps, U. S. military forces. He will have charge and responsibility for the Corps' entire research and development program. This is a new post, created recently. Frolich will have an important part in the Army's scientific professional personnel program.

THE *Petroleum* ENGINEER

Oil..Gas Products Pipelining

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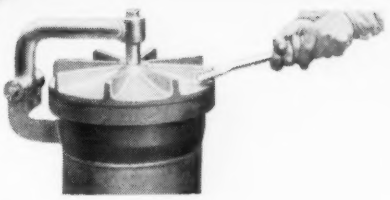

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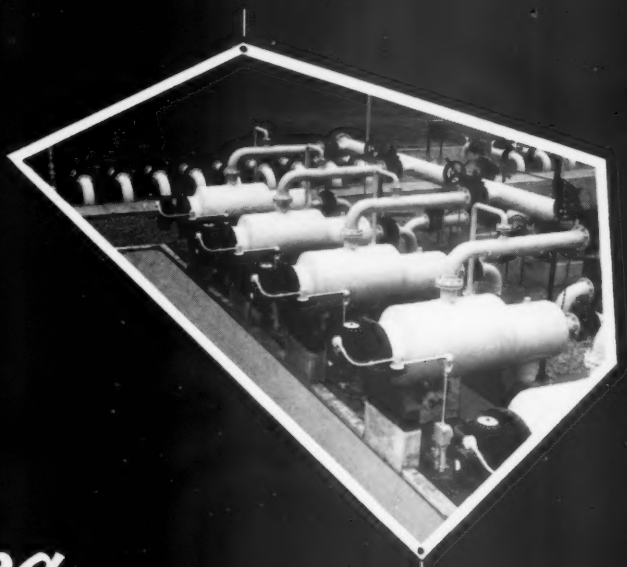

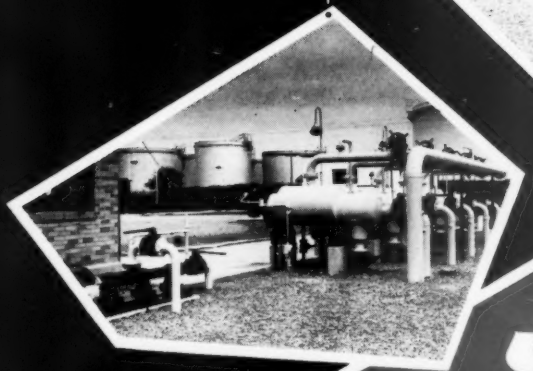

there's a new angle on straining pipeline products

JET TYPE self-cleaning pipeline strainers

When strainers are needed most — a period of about 30 minutes while a scraper is being received — conventional strainers "blind" so quickly that they are of little benefit since they must be cleaned manually and time does not permit this operation. But Jet Type Strainers may be cleaned so rapidly that they can be returned to service **in a matter of minutes,** assuring a continuous flow of clean product through the meters or to storage. Bypassing is eliminated, consequently there is no damage to meters, pumps, seals, dehydrators, etc.

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Big System Planned

Plans for a vast crude and products pipe line system of over 1800 miles have recently been announced. The promotion group is composed of Wiley F. Moore, who promoted the Oil Basin Pipe Line Company now under construction; Jack Frost, Dallas operator, and John MacArthur, Chicago insurance company executive. The $100,000,000 plans include a 350-mile, 16-in. crude line between Glendive, Montana, and Guernsey, Wyoming; a 1000-mile, 18-in. crude line between Guernsey and Coolidge, Arizona, and a 330-mile, 16-in. products line from Wink, Texas, to Albuquerque.

System would also include products line laterals from Coolidge to Phoenix and Tucson and a 50-mile, 8-in. crude line lateral from Denver to the Julesburg area. Two companies are planned —Standard Pipe Line, to build the Glendive-Guernsey line, plus about 200 miles of gathering lines, and the Wink-Albuquerque products line; and the Ar-Mex Pipe Line Company, to build the Guernsey-Coolidge crude line. Two refineries are also planned, one a 10,000-bbl per day plant at Albuquerque and a 25,000-bbl per day plant at Coolidge, to be built and operated by Navajo Refineries and Arizona Refineries respectively.

★ ★ ★

Gas Revenues Reach High

Total operating revenues of the gas pipe line and utility industry reached a record $4,434,000,000 during the 12 months ending June 30, 1954, the American Gas Association reports. This is a gain of $489,000,000 or 12.4 per cent over the previous year.

★ ★ ★

Merger Stretches TGT

Acquisition of the properties of Northeastern Gas Transmission Company has been completed by Tennessee Gas Transmission Company, and operation has begun as an integral part of the TGT system. Merger, approved by the FPC last June, increases TGT's length of 2200 miles, stretching from southern Texas to northern New England. NEGT properties included 533 miles of gas pipe line in Massachusetts, Connecticut, New Hampshire, and Rhode Island. Another TGT merger, with its Tennessee Production Company affiliate, will be voted on by the two groups of stockholders October 6.

Greater Purchases Planned

Three California natural gas companies plan to boost their out-of-state natural gas purchases by 15 to 20 per cent in the next 3 years to keep pace with the state's fast rising fuel demand. The three—Pacific Gas and Electric, Southern California Gas Company, and Southern Counties Gas Company —have signed "letters of intent" with El Paso Natural Gas Company to increase purchases by an additional 200,000,000 cu ft daily by November 1, 1957, according to reports made to the State Public Utilities Commission. PG&E would take half the additional amount, and the two Southern California companies would take the other half. Agreement hinges on El Paso's securing FPC approval to build facilities to transport the gas.

★ ★ ★

Hearings Postponed

Hearings on the proposed 1300-mile American-Louisiana Pipe Line company's Texas-Detroit gas line have been postponed indefinitely by the FPC following oral argument heard September 8, at which company counsel said producers who would supply the line have refused to file for certificates.

★ ★ ★

Conversion Plans Protested

American Pipe Line Corporation, which plans to build an 1800-mile products pipe line system from Texas to the East Coast, has filed a petition with the FPC to intervene in an application by Texas Eastern Transmission Corporation to convert its "Little Inch" from natural gas to petroleum products service. Henry James, American Pipe Line president, says the "Little Inch" would be inadequate since its maximum capacity would be 235,000 bbl daily and would not extend past Pittsburgh, Pennsylvania. James said American's $175,000,000 proposed line would have a 500,000 bbl daily capacity and serve as far east as Newark.

★ ★ ★

Corrosion Meet Set Earlier

An influx of committee meetings has made it necessary to start the NACE's South Central Region Conference in Dallas, Texas, a day earlier. Meeting is planned for October 12-15. Seventeen technical committees have scheduled meetings during the session.

Plan ASCE Pipe Line Meet

Keynote speaker of the American Society of Civil Engineer's Committee on Pipelines' program at the society's annual convention in New York October 21 will be Major General S. D. Sturgis, Jr., chief of engineers, U. S. Army, who will discuss 'Pipelines and the National Defense." Topics on the pipe line program include 'Pipe Line Financing," the Straits of Mackinac crossing, and gas pipe line design.

★ ★ ★

Harbor System Operating

A direct link between Philadelphia area refineries and New York area markets went into operation in September as the Harbor Products System, an 80-mile, 16-in. common carrier, officially went into service. A joint venture, the line is owned and operated by Gulf Refining Company, Sinclair Pipe Line Company, and Texas Pipe Line Company. It connects with refineries of Gulf, Sinclair, and Texaco and reaches terminals of the three companies on the New York harbor. The line also connects with Buckeye's new system to northeastern Pennsylvania and upper New York state.

★ ★ ★

Begin 295-Mile Expansion

Panhandle Eastern Pipe Line has begun work on a 295-mile expansion plan, most of it 30-in. loop lines on its system. Cost of the program is estimated at $22,800,000. Work is part of an overall program costing $66,700,000, announced last May.

Facilities will provide an additional 100,000,000 cu ft capacity daily, increasing the overall daily delivery capacity of 1.070 billion cubic feet. Overall program is designed to increase capacity to 1.425 billion cubic feet daily, 50 per cent above present capacity.

★ ★ ★

New Mexico Line Planned

A rapid tax write-off certificate has been issued by the Office of Defense Mobilization to Malco Pipe Line Company, Inc., of Roswell, New Mexico, for construction of a 91-mile, 6-in. products pipe line between Prewitt, New Mexico and Albuquerque. Allowances were 25 per cent on $1,173,100 and 40 per cent on $88,200.

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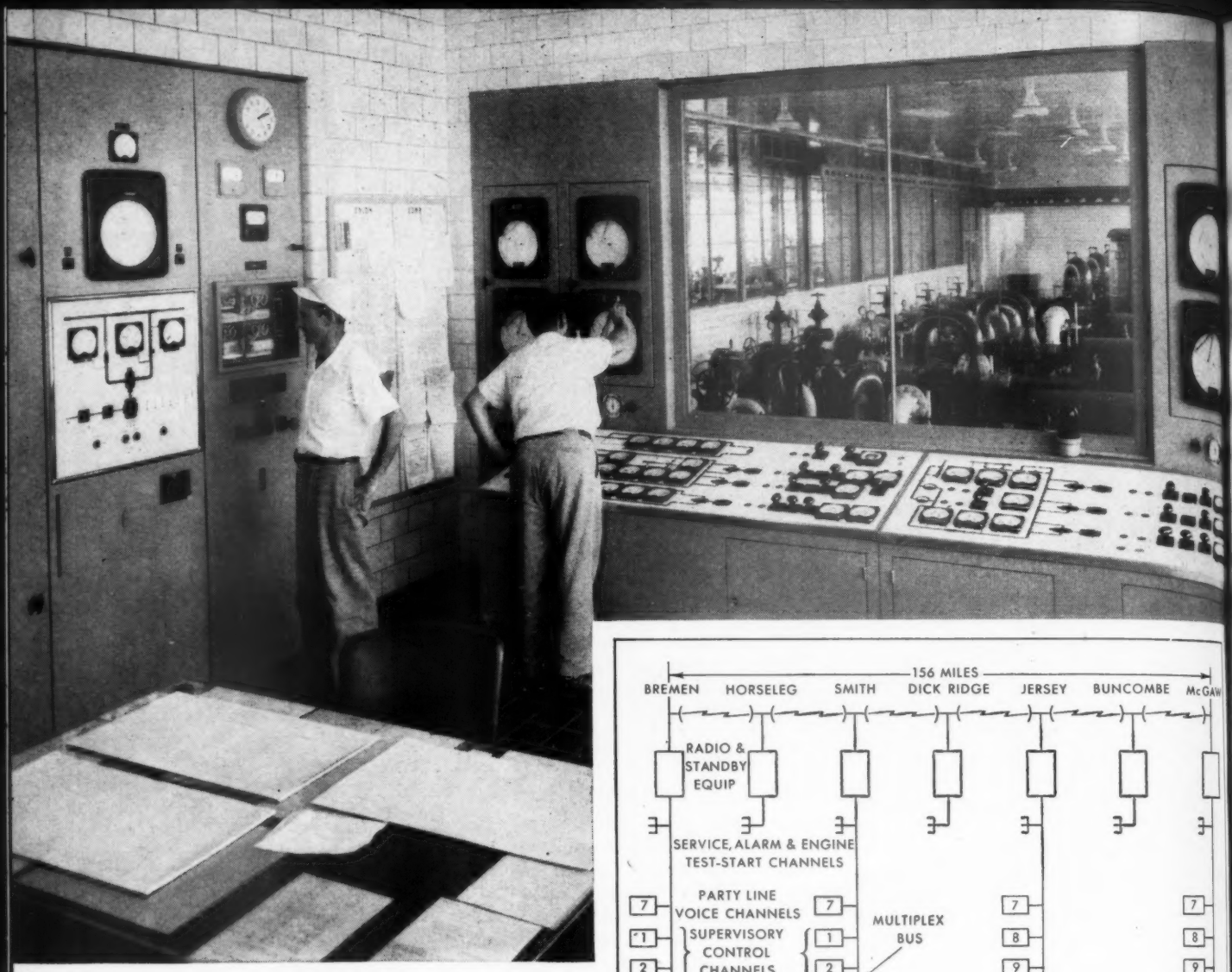

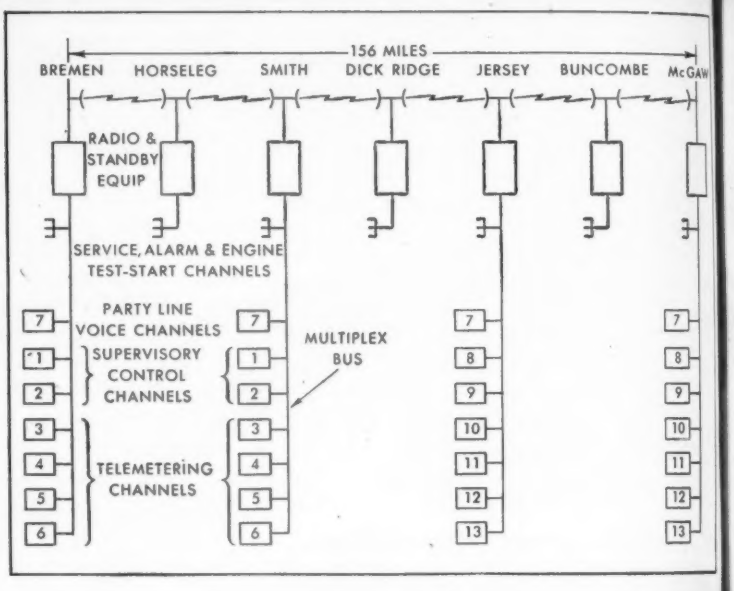

This is the Bremen Station central control room. Supervisory control for Smith booster station is shown at left. All meter and other panel indications are received over microwave. A diagram of the functions provided over the entire system is shown in inset.

The Westinghouse-developed Visicode® combines all the essential remote controls and supervisory indications on a single panel. The three indicators continuously telemeter pressures: pump suction, pump discharge and outbound line. The recorder continuously telemeters flow.

Simplified maintenance is another feature of Westinghouse Microwave. Here, one serviceman checks out the entire system without interfering with working channels. All panels have accessible, built-in test points.

Complete Remote Control of Pump Stations... Over Westinghouse Microwave

Unattended pump stations on Plantation Pipeline Company's North Branch Line are entirely remote controlled over Westinghouse 2000 MC Microwave. Five stations—including the Bremen Control Station—are linked together by Westinghouse Type FR-FJ Microwave Radio and Multiplexing Equipment. It provides all the required supervisory control, telemetering and telephone services, in a completely coordinated system.

On the job for a year, this 156-mile long microwave system has turned in an excellent performance record . . . has given Plantation Pipeline the extreme reliability needed in this type of service.

In addition, system changes are made easy with unique Westinghouse multiplex units. Voice panels adapt easily to any type of telephone service; telegraph units are changed quickly from one function to another. The simple addition—at any time—of the self-contained multiplex panels is all that is required. Thirty channels are available for all types of telephone or telegraphic service. And for extra telegraphic service, each channel may be submultiplexed by as many as 15 audio tones.

Westinghouse Microwave reliability, versatility and flexibility shown on this Plantation Pipeline system can be put to work on your pipeline, too. To get *all* the benefits of microwave, Westinghouse will supply a ***complete*** package, from surveys through installation of microwave and end-use equipment, under a single responsibility.

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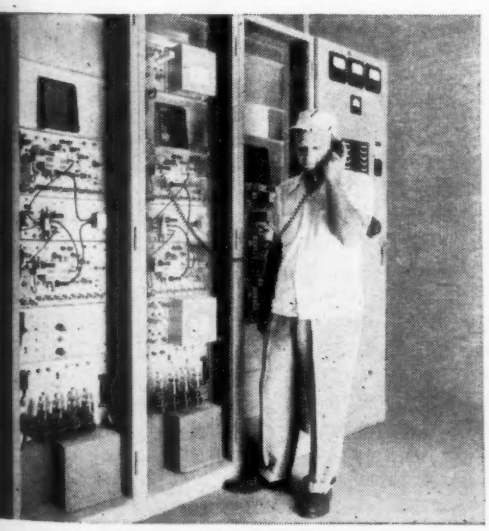
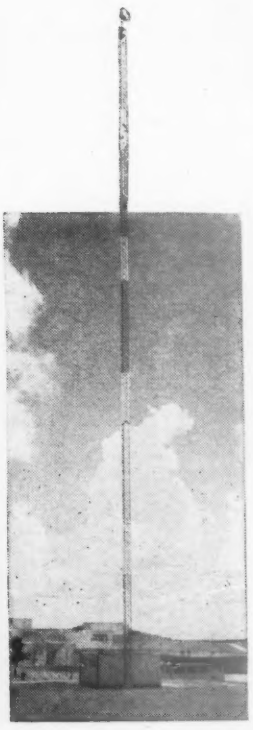


Equipment at Smith booster station includes operating microwave radio repeater assembly, stand-by microwave radio multiplexing equipment and control equipment. Service channel phone gives contact with maintenance crew, speeds servicing.

Smith station supervisory control and telemetering equipment is shown. Panels in center are IT-1 Freq-O-Tron* telemetering transmitters which transmit local pressure and flow over microwave channels.

*Trade Mark



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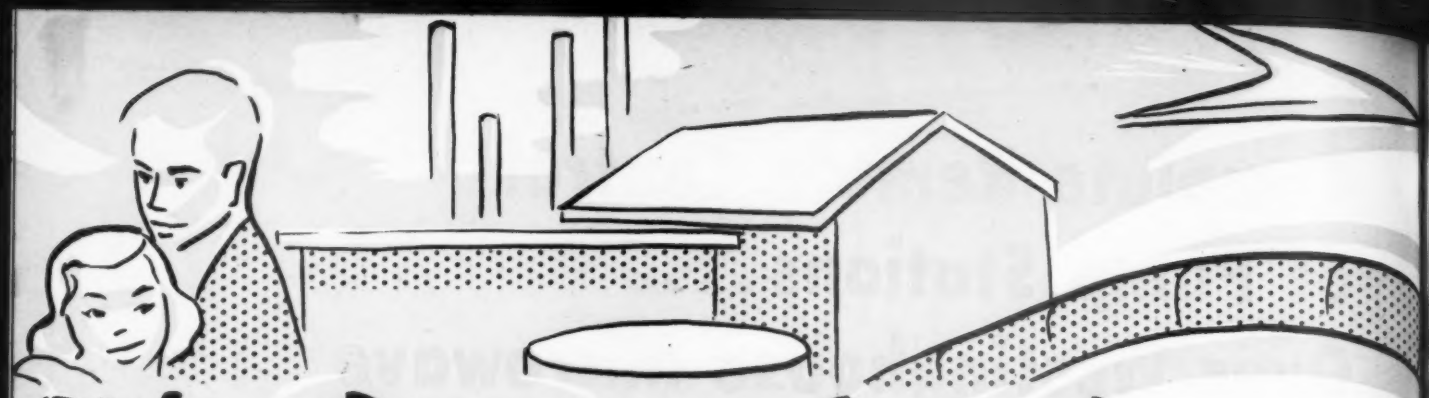


Vast Pipe Line Growth Needed to Serve Expanded Population

Key to the future of pipelining lies in the nation's growth; more people, more markets, more production will mean big increase ahead for pipe line mileage, capacity

By Dean Hale, *Editor, Oil-Gas-Products Pipelining*

What does the future hold for the pipe line industry? Every indication is toward even greater growth in both physical plant and technological developments. Within the next quarter of a century, a 50 per cent increase in magnitude is believed possible.

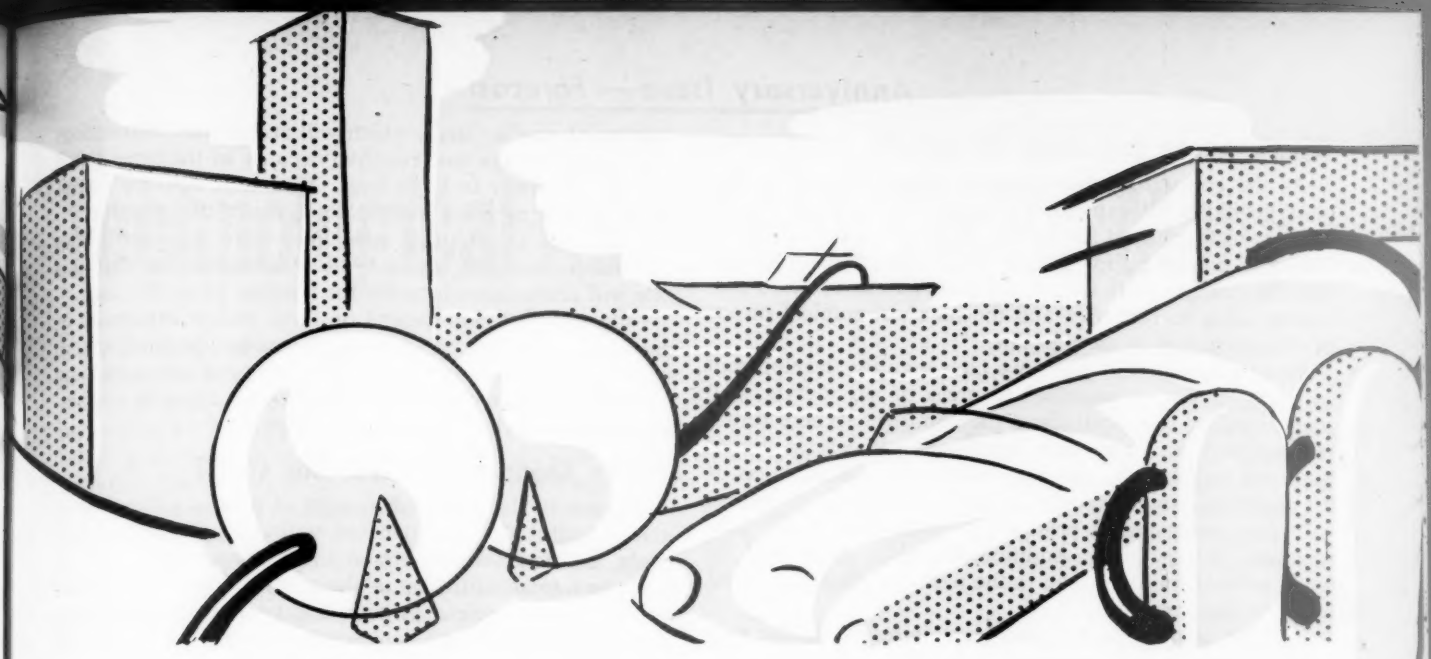
In its first 25 years of publication, *The Petroleum Engineer* has witnessed the pipe line industry—crude oil, refined products, and natural gas—double in size. But how does the future shape up for this amazing type of transportation that has become a "giant" among mediums of transportation?

To find the answer, *The Petroleum Engineer* queried the top management and engineering personnel in all phases, asking their views, estimates, and opinions. In the following pages is a brief report on the answers received.

Pipelining is big business. In 1953, its capital investments totaled $17 billion. In 1954, another estimated $1.8 billion will be added to investments. It will continue to grow bigger. Its growth in a relative short period of time to its present stature is due to many causes, of which the most important are the facts that it has accepted and put to use technological advances, and that it has had resourceful management, which has continually built toward the future.

Why So Much Optimism?

Because pipe lines primarily are "supply lines" between sources of products they carry and the ultimate consumption points, their existence is intimately linked to population and market growth. As these two factors grow, so will the nation's pipe line networks. The expansion of the oil



and gas industry will be geared to markets and population, and it is inevitable that the oil and gas industry's principal form of transportation will grow accordingly.

Markets Are the Key Factor

Market growth is inevitable. Markets are made by people, and according to the U. S. Bureau of Census in its projected figures, the nation's population is steadily increasing. Within the next 25 years, a total of 225,000,000 persons will inhabit these United States, an increase of approximately 40 per cent above the present 160,000,000.

These 65,000,000 new consumers will need more of everything—homes that will require heating from some source, automobiles and trucks for personal and public transportation, products from industries that will need heat, lubricants, fuels, and petrochemical supplies. Competition between sources of energy will be keen, but oil and gas will continue to be the principal sources.

To meet these future demands, production of oil and gas will have to be stepped up. New reserves will need to be developed, reserves in present fields will be recovered to a greater extent through new methods and processes, more refineries and processing plants built. The tying link between these points will be pipe lines—many thousands of miles of pipe lines still to be built and operated.

Present operating companies will continue to expand, new companies will enter the field, more people will be employed, more equipment needed, more services and suppliers required. The overall picture, *The Petroleum Engineer* believes, looks extremely good.

The increase in population during the next quarter-century is estimated at 40 per cent of the present population. Demands for oil and gas, however, most likely will be even greater. A bare minimum would be a 40 per cent increase in production of both.

It is usually safe to predict the future on past performances. What's happened in the past 20 years may provide an insight to the future. During the 20-year period, the population increased by 37,000,000 people, while the number of families increased from 30,000,000 to 46,000,000. During the same time, there was a transition from rural to urban population, and today approximately 65 per cent of the people in the United States live in urban areas.

To the natural gas industry, this growth and shift of population has had a big impact. In 1933 the natural gas industry had 5,000,000 customers compared to 10,000,000 using manufactured or other gas. In 1953, there were 20,000,000 customers using natural gas, only 7,000,000 using LPG, mixed, or manufactured gas.

Part of this customer increase of 15,000,000 was due to conversion from other types of gas. A large part was converted from other fuel sources, such as coal, wood, and fuel oil. The balance was from new homes and industries. Customers in the past 10 years have been added at a rate of about 600,000 per year.

Demand for oil has grown rapidly in the same period. A barrel of crude gives up many more products today than it did 20 years ago, largely because of the "magic" of petrochemical developments. People are also traveling more, using more products that require fuels and lubricants, and industrial uses have expanded.

Motor vehicle registration 20 years ago was 25,000,000. In 1953 the figure was 55,000,000, a growth of 120 per cent over 1933. More vehicles being driven more miles means a vastly increased demand for fuels and lubricants. Other products from petroleum are continually increasing, too. The global political picture isn't destined to change much, many observers feel, and military demands will continue to be high for many years.

There Are Other Factors, Problems

In addition to the general observations about the future, there are a number of immediate and pertinent factors that deserve consideration. All will have an effect on the future.

More joint ventures are foreseen in the areas of crude and products lines. Joint ventures in natural gas transmission are possible, but not likely under current federal regulations. Continuation of the joint venture method of organizing, building, and operating new lines can be expected provided no governmental restrictions are applied. Joint ventures are favored when economics are in favor of multiple ownership of a large diameter single line contrasted to individual ownership of multiple small diameter lines serving common areas. Total investment and transportation cost are much less in joint ventures.

Competition is and will continue as an important factor in pipe line expansion. Competition will not only be between various companies, but the competition between sources of energy will grow keener.

Replacement of older pipe line systems, mainly those that are of small diameter and often multiple line systems, will be an important part of the changing pipe line picture.

Federal regulations, particularly in the natural gas field, could be a deterrent to expansion. Most observers feel, however, that the current controversy over regulation of producers will be solved through new legislation and that it will be soon. The fewer governmental restrictions applied, the better industry will prosper.

XUM

What's Ahead for Crude Oil Lines?

As the consuming public grows, along with its accompanying industrial expansion that will provide goods and services to be utilized in the increased market, the demand for crude oil needed for processing into petroleum products will increase proportionately. Oil must be moved from producing areas to refineries and the most economical means of transportation is the pipe line.

Within the past few years, we have seen the development of many "areas of promise" to areas of production, and such areas are scattered across the continent. Where future reserves will be found and developed is uncertain, but if the trend follows past patterns, expansion to other areas of the continent can be expected. Carrying this crude to market will mean extension of present pipe line systems and construction of new lines. Additionally, older fields will be made to yield more oil than in the past, increasing the need for pipe line capacity.

Reliable sources in the petroleum industry believe that future demands will increase about 4 per cent annually. Refinery capacity, presently about 14 per cent above runs to stills, is expected to continue increasing. Approximately 90 per cent of the runs to stills are domestic production and 10 per cent of crude processed is imported. This trend may continue, assuming that import levels remain at about 10 per cent of demand. There will still be vast room for expansion of domestic production.

As reserves to meet future demands are developed, both in new and old fields, pipe line capacity will have to be increased accordingly, and new outlets constructed. More and more new fields are being discovered each year and as they are brought into production, it is necessary to build gathering systems and connections to trunk lines. Consequently, gathering system mileage construction will have to increase annually.

In the period of 1947-1953, the yearly average of new crude line construction was about 5000 miles per year. This rate of construction was higher than is foreseen for the future. Chief reason is that many new projects will be joint ventures and the advent of large diameter systems will provide adequate capacity and eliminate the need for parallel, competitive lines. A minimum of about 3500 miles of new crude line per year is predicted by industry observers.

What's Ahead for Products Line?

In the 25 years *The Petroleum Engineer* has been published, products pipe lines have grown from a virtual nothing to over 31,000 miles. Much of this construction has been since World War II. Long distance petroleum products transportation originated in the Southwest United States and has since grown, like the proverbial snowball, to a vast network of lines that touch every sector of the nation.

Their growth in the past quarter-century, however, will be considered small against the systems of the future, say industry observers. For products pipe lines are the cheapest form of transportation, much lower in tariff than tank cars, truck, or marine transportation. And they have a prime advantage in that they can be extended practically anywhere.

Eventually, believes *The Petroleum Engineer,* trunk products lines will reach every major city, and smaller cities and important distribution points (farm and industrial) will be reached by small diameter feeder lines. As with natural gas and crude lines, expansion will be related to population and market growth.

More cross-country trunk lines will be built, many as joint ventures, others as shipper-owned lines, and some privately-owned lines. Many thousands of smaller distribution lines, from major terminals to bulk plants, and even to large volume service stations will be built. Some predicted future developments see greater flexibility in handling more batches of smaller sizes, which will accomplish tremendous savings in tankage now required because of the large batch sizes, particularly in large lines. Automatic delivery equipment now being made available will make this possible.

Expansion of products pipe lines have averaged about 3000 miles annually since 1947. Predictions are that this rate will continue or increase for another 10 to 20 years.

Future growth will depend on three things: expansion of present systems due to increases in market demand, extensions to new areas as consumption demand increases, and construction of new systems from refining areas to marketing areas not presently served by pipe line.

What's Ahead for Natural Gas Lines?

Because of the many advantages of natural gas as a fuel, it is doubtful that the demand will ever diminish. More likely, demands will continue to increase and there will never be a total saturation of the market. Territorial expansion is about complete, as natural gas service to the Pacific Northwest is completed as planned; the next step is regional expansion within existing market potentials.

In the highly populated, heavily industrial areas of the northern and eastern states demands for natural gas are nowhere near a state of equilibrium. Long waiting lists of new customers are current problems with companies in these areas. Increased population, through the coming years, and the inevitable expansion of industry, will result in greater demands on energy supplies, and natural gas will be a chief source of supply.

To accomodate these demands, utilities will have to expand greatly. Present gas transmission systems aren't big enough either. Expansion must come through new lines, parallel lines, and loop lines plus additional compressor horsepower on exising systems.

In a 20-year period, marketable production has grown from 1.55 trillion cubic feet per year to 8.4 trillion cubic feet in 1953. If future growth should continue at this rate of about 350 billion cubic feet per year it can easily be seen that transmission capacities will have to expand vastly. It will probably be greater, with some sources predicting yearly increases of 500 billion cubic feet.

Development of new reserves will be the "make or break" factor in this expansion. Most industry observers feel that new gas supplies will be developed, but not in the concentrations of large fields as has been true in the past. With production of gas more scattered, there will be a higher rate of construction of gathering and supply systems to feed the transmission companies' trunk systems. Relationship of supply to point of consumption will be more diverse, and operations will be strung out. The possibility of interconnected systems is also being considered, and assuredly could reduce the complexity of future operations.

Construction is seen as continuing at a high level, although somewhat lower than in the peak years of 1947-1953. During that period, nearly 57,000 miles of gas lines were built, an average of over 8000 miles per year. Observers see a more realistic rate of about 6000 miles per year.

Two typs of construction are foreseen. Cross-country transmission lines will use larger diameter pipe with its higher capacity. A network of smaller diameter lateral "take-off" lines to many more smaller communities will add to the vast network. Most of this construction will be in areas still considered undeveloped by the natural gas industry.

Distribution lines will also greatly expand. Many miles of mains must be laid to reach the many new customers, and much of this type construction will utilize plastic and aluminum pipe, observers believe.

Summing up, the prospective growth in consumption of natural gas will make imperative a tremendous expansion of gas pipe lines to provide much-needed additional capacity.

Technological Advances To Be Many...

PREDICTING exactly what's going to happen in the future is like selecting three consecutive "daily doubles" at the racetrack . . . it's not easy. To get a better line on what can be expected, however, *The Petroleum Engineer* surveyed engineers, operating people, and suppliers for their ideas.

The adjectives used to describe what's ahead could be found in every letter—more, bigger, better, greater. A preface to one reply sums up the art of predicting the future and is well worth quoting: "Anyone who attempts to prophesy what will happen in this modern scientific age is some sort of a nervy individual whose judgment could well be questioned . . ."

In the following paragraphs will be found a concise condensation of what the pipe line industry feels will happen in its future.

Present trends in the design of stations and pipe lines will continue. More and more large diameter pipe is going to be used, with major natural gas transmission lines turning to pipe as large as 48-in. Currently, the first 36-in. pipe is being laid and much valuable experience in construction is being gained, as will operating experience in the months after the line is put to use.

Large diameter pipe will also be used on major cross-country crude oil lines, particularly where such lines are joint venture projects. In the products pipe line field, where phenomenal growth is predicted for the next quarter century, many trunk lines can be expected, and pipe size will be much larger than current practice.

Stations, both pumping and compressor, can be expected to become more compact with the development and application of more powerful prime movers that will make the requirements for unit numbers smaller, and with the increased use of automatic and semi-automatic control systems.

Station spacing will tend to grow increasingly wider and many stations will be completely automatic and remotely controlled.

A major technical advance that will affect both station and line operation and design will be the use of alloys and better steels in line pipe. Higher strength pipe will allow higher pressures. Alloy pipe, in addition to strength, may be developed with built-in corrosion resistant properties.

Other materials for pipe are gaining in favor in certain phases and will find increasingly greater application. Aluminum pipe, lightweight and easy to handle, can now be welded with ease and will find use in small lines and in gathering systems.

Plastic pipe, available in many forms, has advantages in weight and corrosion resistance and is being used in many gathering systems and low pressure service. As methods of reinforcing plastic pipe are developed, plastic pipe will undoubtedly find wider application.

Operations in general will make use of advanced techniques as they appear. Many replies to *The Petroleum Engineer's* survey noted that company efforts were directed not only at developing the future, but also in "keeping up with current new ideas."

Major emphasis in future pipelining will be towards more efficiency. Competition will continue to force the pipe line industry to find and make use of new technological advances.

Building and operating automatic stations has become a question of economics, not feasibility. Better use of scrapers and application of internal pipe coatings will make possible higher flow efficiencies. Crude oil lines will have to develop better techniques in handling of the more volatile liquids that are being tendered to them in ever-increasing quantities.

A fertile field for automatic operations will be both crude oil and gas gathering systems. Many companies have already begun work in these fields on the problems involved.

Keener interest in controlling losses occurring in transporting, storing, and handling finished petroleum products is manifest in the industry, and long range results should provide greater savings of actual petroleum products and money.

Higher velocities in multiproducts lines are forecast as methods for maintaining the interior surface of lines in good condition are improved. When this is done, the use of either mechanical plugs or some type of gel as a separating medium will become common practice.

Automatic control equipment that will permit delivery of products to small, intermediate terminals and large volume bulk plants at times when such locations are unattended, should reduce transportation and distribution costs.

Dispatching practices will benefit through the adoption of electronic analyzing and computing machines that will be able to solve complicated dispatching problems in seconds.

Electronic calculators will also be adopted for use in every phase of operation from accounting to welding records, speeding up functions and reducing costs.

Control systems—supervisory controls, telemetering, remote gaging, etc. —will become increasingly greater in scope and application. At some future date, it may be possible for a dispatcher and two or three assistants to operate a complete pipe line system from one central location, with only supervisory and maintenance personnel needed up and down the line.

For many years the trend has been to transport natural gas in larger quantities and for longer distances, requiring larger lines and higher pressures. If, for example, petroleum and gas could be developed in the Arctic Circle in commercial quantity, a chemical approach could be used to solve the transportation problem. The approach would be to chemically convert crude oil—readily and economically—into natural gas, followed by a reverse process that would allow gas to be converted into a heavy, high Btu value liquid of perhaps 1,200,000 btu per cu ft value, which corresponds to API 10 gravity crude.

Gas of 1000 Btu heat value compressed to 800 psig contains 63,000 Btu per cu ft. This is about 10 per cent of the heat value of the liquid mentioned above. Therefore, a 12-in. liquid line could conceivably carry as much fuel as a 48-in. gas line at about the same pressure or a 60-in. gas line at a slightly higher pressure on the liquid line.

In the communications field, even greater use of radio and microwave is foreseen. Microwave will eventually replace wire lines on all long-haul communication service with 100 per cent reliability, greatly increased flexibility, and lower cost per channel-mile. This will permit operation and remote control of essentially unattended compressor and pumping stations.

Application of television to pipe line operations is another fertile field. Application to an integrated microwave-VHF radio system would permit supervisor and dispatching personnel to continuously observe operating conditions

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at all critical points on the system as well as construction and maintenance work in progress.

Reliable remote control of pipe line gate valve operation, both main line and at wells, will be available.

Portable TV link equipment will permit observation of major repairs, flood conditions, and other factors affecting the safety of the pipe line when needed.

Selective calling of individuals, equipped with pocket two-way radios will permit complete intercommunication between all key personnel associated with an organization, either office or field, at any time without restriction of locations.

Unit equipment for communications service will grow more and more compact through use of transistors, miniature tubes, and other electronic advancements.

Regardless of the beginning or end, the oil industry centers around the point of custody transfer—the "cash register"—where measurement procedures are conducted. Great improvement is seen in this area.

Hand gaging of tanks will eventually be replaced by numerous forms of automatic measuring devices. Accurate measurement of flowing crude oil for use as a basis for custody transfer will permit elimination or reduction of tankage at points between different pipe lines and at refineries, with subsequent reductions in investment, operating expense, and evaporation.

While automatic gaging and sampling techniques for custody transfer of oil are still in the experimental stage, results obtained so far are apparently satisfactory. Improved equipment and less expensive installation methods will mean greater utilization of this practice.

Meters have been used satisfactorily in products pipe line service for some time. Recently, meters were installed on a large diameter, big capacity crude line to make custody transfer for the first time. Greater accuracy and reliability in meter design and performance, certain to come, will eventually mean the near total elimination of hand gaging.

In gas measurement, a precise science today, some observers predict that orifice meters will be replaced by newer, simplified methods and equipment. Forecast are instruments that measure, compensate, and record instantaneosuly, giving records that need no further calculation other than computing total purchase costs of gas delivered.

The search for high horsepower, packaged in as small a unit as possible, for use as a prime mover, may be near. This is the gas turbine now being made

The Future

Management To Have Big Job: No Shortage of Problems Seen

By George A. Wilson

WHEN commenting on the future of the pipe line industry, it is customary to discuss the technological trends and the physical growth in terms of new facilities. In addition to these aspects of the business, there is another subject not too frequently surveyed, but which is always a part of the pipe line panorama—past, present, and future. This subject is *management* and it should be of interest to review some of its responsibilities in the years ahead.

For the first time in several years, the domestic economy is operating under conditions resembling those of a normal peacetime prosperous economy. True, defense spending is a prime factor in the overall level of business activity and according to current forecasts will continue to be for years to come. Practically all materials for industry, however, are readily available, delivery schedules are reasonable, and products are actively seeking the consumers. The healthy influence of competition is again being strongly felt in many industries and the oil industry is no exception.

Within the industry, crude oil pipe lines in particular have felt the physical and financial impact of less-than-capacity operation beginnng in late 1953. Barring a war or unexpected international developments, it is to be expected that a more normal competitive situation will continue to exist for an indefinite period of time. With this prospect for the future, it would be well for management to critically analyze the performance of its functions and determine the changes that may be indicated in preparing for the oncoming years.

One of the decisions that management must make from time to time is whether to build new lines and/or expand existing ones. Pipe lines are built for long years of service and tariffs are set at low levels which necessarily require many years for them to pay out. In recent years, the unprecedented high demands for crude oil transportation via pipe lines have been such that new facilities often were operating at capacity soon after completion and in many cases years ahead of schedule. If management's decision was faulty, unanticipated volumes assisted in remedying what otherwise may have proved embarrassing. Now, with a reduced rate of growth probable, it is imperative that very careful consideration be given to expansion. This does not mean that the outlook is not optimistic but rather that the quality of judgment displayed by management will be more readily apparent than in recent years.

Besides the considerations involved in building new facilities and enlarging existing plants, there are present today and likely to continue for some time financial and personnel problems in connection with systems operating below capacity.

Management will need to give more attention to long-range planning. The press of construction in some cases may not have permitted adequate efforts in this direction for the past few years, but with much of this over, time will now permit the formulation of long range programs in those instances where they have been neglected. Such programs should be periodically re-examined and current happenings appraised in the light of the overall program.

It is timely that organizational structures be reviewed to ascertain if they are satisfying present day and future requirements—not only in operations but in the general office. With pipe lines of the future emphasizing automatic and controlled operation as contrasted to manual in the past, with added mechanization of accounting departments

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George A. Wilson

and more compiicated engineering required, management must be certain that the organization is equipped to keep pace with the changes. Too, in the rapid expansion of recent years, the resulting organization both in new and old companies may have grown so fast that it may bear little relation to that originally intended or that necessary for the future.

Personal relations should receive more, not less, attention from management in the future. As a result of modernization programs, companies may presently have surplus employees. Where temporary in nature, the problems that arise may not be particularly difficult. But where the surplus is likely to be of long duration, the serious problems involved call for fair and considered action on the part of management and industrial statesmanship based not altogether on the immediate profit picture but on sound principles, which will over the long period yield the optimum benefits to all concerned.

Where new machinery and techniques are introduced within a company, management's desire to fully utilize them is only partially fulfilled if not accompanied by proper training. The maximum potential of modern equipment is not realized if the people charged with operating it are not instructed as to how best to use the equipment. For example, where trunk line stations with multiple electric centrifugal units are operated at only partial capacity, power may be wasted and the pumps operated in an inefficient range if management has failed to train the men as to the optimum operating methods. When hiring new employees, it is well to remember that operation of future pipe lines will demand more education and skill than has been required in the past and standards for new employees should be set accordingly.

With technical personnel continuing in short supply, conscious efforts on the part of management to make the most efficient use of them is called for. It is unfortunate and uneconomic when companies hire and train technical personnel and then do not fully utilize their abilities. In training technical employees, the recent trend of stressing human relations will no doubt continue. On executive development, the first step is to ascertain the needs of the company, and then plan and maintain a program that fits the requirements.

Cost reduction programs will be emphasized in coming years. Management will want to be certain that the programs reduce costs, not merely shift or re-allocate them. Such programs should not only encompass operations but management itself. Problems are posed when management becomes top-heavy but it is certainly preferable to ascertain these situations and develop corrective measures rather than ignore them. Too, employees recognize when only the lower levels of organization are subject to cost screening; such restrictive screening is not conducive to good employee morale.

In summary then, it can be said that the coming years will see no shortage of problems for pipe line management, and that they will quite likely require more real thinking on the part of management than has been the case in recent years. The situation is analogous to the position of the salesman in the seller's market during the post-war period—he was in reality an order taker. With the advent of the buyers' market, the salesmen are new being separated from the order takers. Likewise, in pipe line management, it will be possible to distinguish the more capable members from those who are less competent. * * *

available in ranges of 100 to 500 hp and suitable for driving small pump units and compressors. Previous installations of gas turbines have all been in the gas pipe line field, with large 6000-hp units driving centrifugal compressors. These have been satisfactory, but the non-availability of a wider horsepower range has limited the application of the gas turbine.

Engines and electric motors are also broadening in range of sizes. Latest prime mover product developed is a 3200-hp gas engine that will meet the needs of operators wanting something bigger than present big engines (1500-2000 hp) and yet smaller than the tremendously powerful 6000-hp turbines.

Extensive use of the free piston engine is predicted in coming years. Connected to a gas turbine, one observer notes, it would seem almost ideal for generation of power on variable throughput products pipe lines.

Increased efficiency is an immediate need for most types of prime movers. This will be accomplished through improvements in design and application of recently developed engineering principles, such as better design of heat exchangers that will make for greater economy in installation and operation of gas turbines.

Electric motors are also getting bigger, with sizes now available up to 2000 hp and experimental work being done on models as big as 3000 hp. Where economics make it possible, pipe line pumping and compression operations will become increasingly electrified.

The trend toward simplification of design in compressor stations will continue, creating additional demands for more powerful but compact compressors.

Centrifugal compressors will find a wider application on compressor problems as designers develop more flexible machines. All types of compressors will improve in performance and efficiency.

A tremendous expansion in portable compressors for field compression, both with reciprocating and centrifugal compressors, can be expected. Gas turbines of small horsepower driving centrifugal compressors, completely automatic and weather-proofed, will share in this field compression.

Larger lines and bigger prime movers will also mean that pumps will have to grow in size and efficiency. Better materials of construction will be utilized, and increased capacity and higher pressures will be possible.

Corrosion engineers will find their problems more extensive in the future. More attention will have to be given good underground coatings as cathodic protection installations continue to in-

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crease, because large quantities of protective coatings involved in the protection of underground structures in some congested areas create complex problems in avoiding undesired results.

Improved external coating using plastics will find widespread use and provide superior protection to coatings presently used.

Suggested possibilities towards corrosion prevention are the use of alloys with "built-in" properties, mill treatment of steel both externally and internally, and materials other than steel.

More attention will be given to pipe interiors to reduce friction. This may be done by electroplating, plastic coatings, or ceramic coatings. If any of these coatings could be made so that they are preferential water-wetting and and oil repelling, it would then be possible to pump any viscosity oil with the friction factor of water.

More and more research will have to be done. Many companies have set up special research departments, some equipped with complete modern laboratories. Others participate in joint research ventures with colleges, universities, other pipe line companies, and with industry.

A continual review of equipment can be well afforded by the pipe line industry. Many problems need to be investigated, such as steel fractures, pressure surges, cavitation in pumps, and stresses in pipe lines from both engineering design and operating standpoints. This would permit more efficient and intelligent use of pipe lines.

All pipe lines in the future will be safer even though pressures are higher, because of improved quality of material and improved methods of construction and testing.

Development of the ASA piping code is a big step forward, in both safety and design principles. Safety is important not only from operational standpoint, but also to public relations.

Development of better and cheaper construction equipment and methods will be encouraged by pipe line companies. This has been left up to contractors in the past, and while they have done a commendable job, companies pay the bills and in the interest of economic investment and operation, will make efforts to reduce costs.

Equipment for construction will be bigger and better. This will be necessary for the laying of the larger lines of the future. More pipe will be yard coated and wrapped to save time and money. Better methods of field jointing will be developed. Automatic girth welding machines will be used for field welds, speeding up construction.

At some remote date, pipe line construction will be completely changed, several engineers predict. They foresee a complete, mobile plant moving down the right-of-way, supplied with raw materials in bulk form to permit fabrication of a continuous reinforced plastic pipe line, installing it as it travels.

Storage problems will find their solution underground. Gas pipe line companies will expand underground storage activities to meet the immense peak day loads of the future.

Underground storage of LPG will be followed by similar practices for crude oil and products. Abandoned quarries will be increasingly utilized for crude storage. The first of these quarry projects is now being tested.

A future field for pipe line ventures, whether constructed or owned by producers or pipe line companies, is the service of offshore wells. For oil wells, pipe lines will greatly minimize if not completely eliminate the weather factors that hamper barging operations. Transportation cost is cheaper by pipe line and producers' investments in costly storage facilities offshore can be reduced.

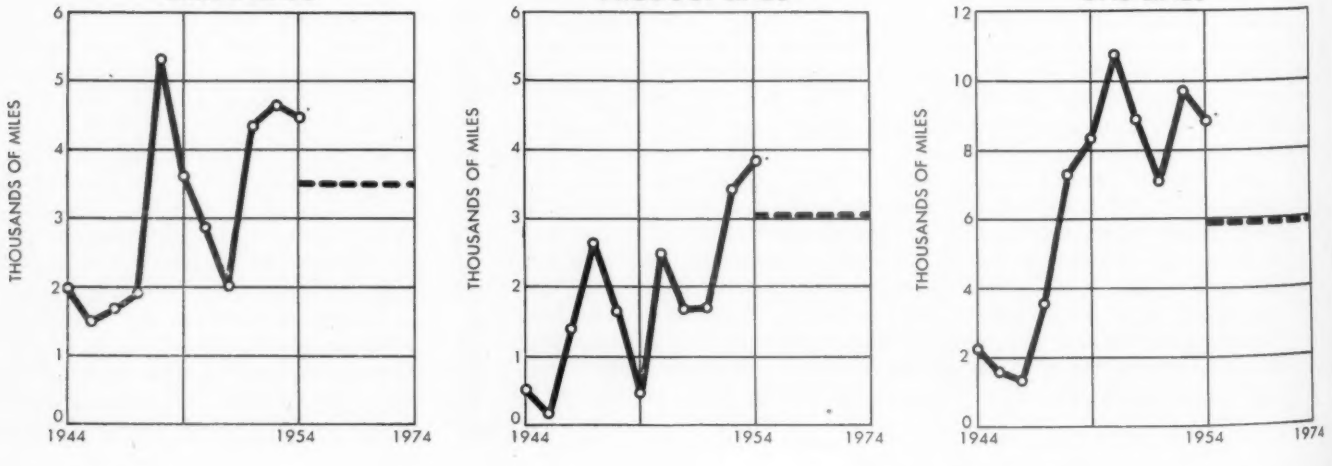
It may occasionally be preferable for a single line to handle both oil and gas, bringing them to shore before entering separator and storage tanks. Those who build offshore lines will have to analyze their design, construction, operating and safety practices. Some radical changes in current thinking in these areas may be necessary as problems are much different from those encountered on land. Corrosion controls must be directed towards complete prevention, not retardation.

Offshore producing operators have found it necessary to enter actively into the development of new drilling equipment and techniques as problems and cost were too much for contractors to handle alone. Similarly, those paying for offshore pipe lines may have to encourage and assist in the development of new construction practices rather than leave it to the pipe line contractors to work out.

Another future area for pipe lines is the connecting of refineries to storage, mostly underground, in areas removed from the refineries where such storage can be provided at substantially less cost. Pipe lines will be needed to move fuel oil and LPG to and from these storage areas. Where several refineries are in one area, these could well be joint venture lines.

CONSTRUCTION ACTIVITY in the next 2 decades can be expected to approximate a level of about 10,000 to 12,500 miles per year, including gathering, lateral, and trunk lines. This construction will result from expansion of present lines to meet greater demands, replacement of high operating cost systems, and new systems to serve new producing and/or market areas. Many areas of the United States and Canada not now served by either gas or products lines will be linked to the present network of over 600,000 miles. Graphs below depict the predicted future construction activity.

PIPE LINE CONSTRUCTION
1944-54 ACTUAL AND 1954-74 PROJECTED



Quarter Century of Progress

TWENTY-FIVE YEARS OF SERVICE to the petroleum industry has been reached and is being observed with this issue of *The Petroleum Engineer*. During the quarter-century span that has just passed, the pages of *The Petroleum Engineer* have helped to both make and record the fascinating history of the oil and gas industry.

As the first publication in the petroleum industry dedicated to the engineering, operating, and technological aspects, it rapidly became an important 'middleman' in the exchange of information on the latest developments in equipment and methods.

A trail-blazer in the petroleum publishing business, *The Petroleum Engineer* was the first trade journal to give general coverage to pipe line construction projects with its timely reports on construction, engineering design, and operating features of new pipe lines as they were built. Among these "firsts" were articles on cathodic protection for pipe lines, and automatic control of pipe line stations.

Specialized Edition

As the industry became more complex and problems more numerous, the trend towards specialization arose within the petroleum industry. In keeping with this trend, *The Petroleum Engineer* in 1948 introduced its selective publishing plan, with specialized editions designed for each phase of the oil and gas industry.

For the men in the crude oil, petroleum products, and natural gas pipelining phases of the industry, the new "Oil and Gas Pipelining" edition was a magazine of their very own, bringing them up-to-the-minute information on new methods, new equipment, the latest in construction practices, and a year-round report on the pipe line industry's people, projects, and developments. Attesting the growth and importance of this first specialized "pipe line" engineering and operating magazine is the fact that it has the largest paid circulation among pipe line operating people of all petroleum trade journals.

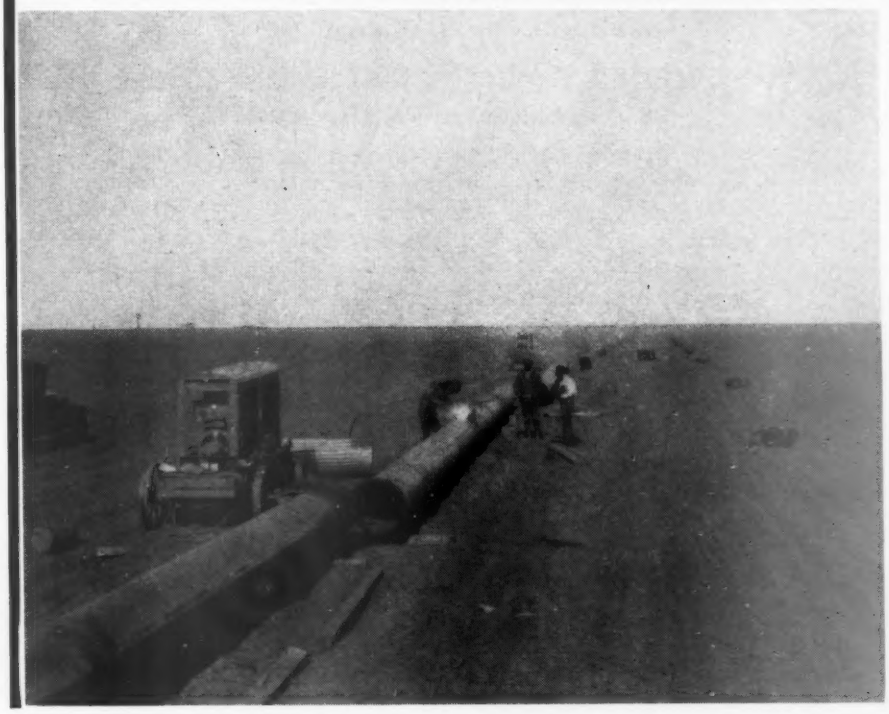
Developments in 25 Years

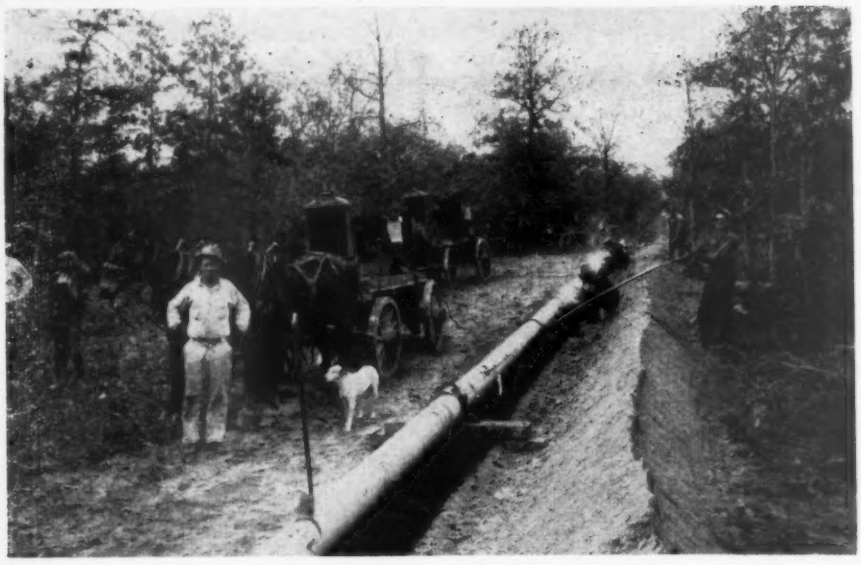
In 1929, the year that *The Petroleum Engineer* was founded, the first successful use of electric welding was made on a 169-mile crude oil line in Texas. This was the first long-distance line successfully constructed in this manner and opened the way to greater use of the arc welding technique, now used universally.

Pictorial Review

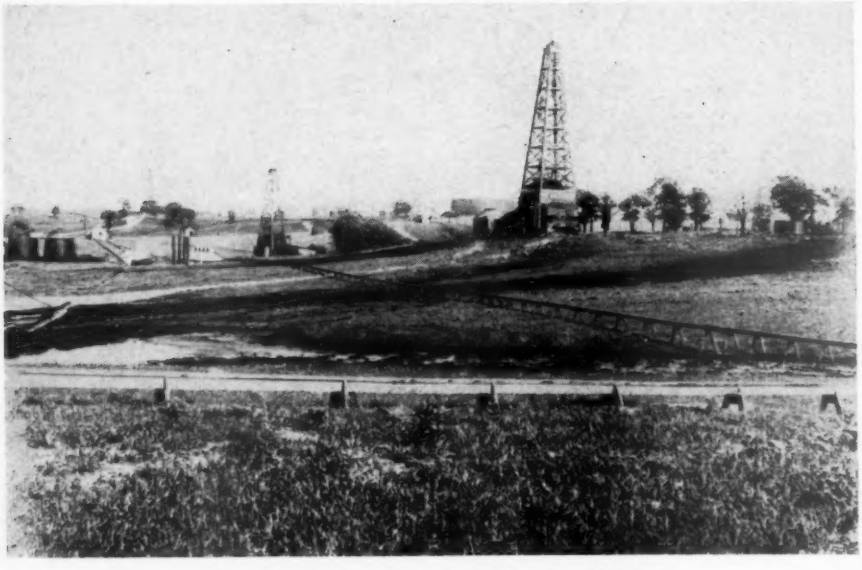
Above, hot bending like this has been replaced by modern bending machines.

Below, firing line, 1930 style, on 24-in. gas pipe line, was early electric weld project.





Making tie-in on 8-in. crude line in Texas.



Above, gathering lines in Oklahoma, 1930's.

Below, pipe stringing crew in Texas, 1920's.

Seven major pipe line projects in 1931-32, including the first long-distance, large-diameter natural gas pipe lines from the Texas Panhandle to the Mid-West, were big news. Varied and unusual construction methods were tried, including the laying of twin 10-in. lines in a single ditch, the first trunk line products system from the mid-continent refining area to the Great Lakes marketing areas, and a 760-mile 8 and 10-in. crude line from Oklahoma to the east.

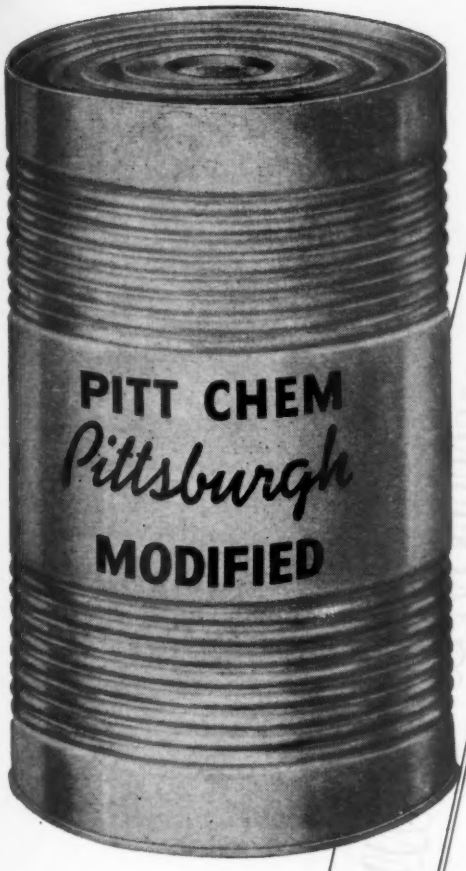
Several major developments appeared on the construction scene in the 1930's. In 1933, a method of pipe welding that eliminated the back-up ring was introduced, and in 1936, the stovepipe method came into use. In the late '30's, line-traveling machines that could clean, prime, coat and wrap were perfected, replacing the old, tedious method of doing it by hand.

War clouds on the international horizon hastened many new pipe line projects and a construction boom started that saw nearly 5000 miles laid in 1939, 8000 in 1940, 7500 in 1941, 1942, and 1943. Mileage completions during the 1944-45-46 period were low, due to material shortages, but picked up and have since been high.

Big projects of those times included the Plantation Pipe Line system; the War Emergency Pipe Lines—a 24-in. crude line and a 20-in. products carrier, both from Texas to the East.

In 1945, the "big-inch" lines were converted to gas and transported 50,000,000 cu ft daily to the East. Gas from the southwest branched westward with a 26-in. line from the Permian Basin to California.

In 1947, a new company, Texas Eastern Transmission, took over the "big inch" lines, and installed the first high pressure centrifugal compressors driven by electric motors. In 1949, a revolutionary development in prime movers, the gas turbine, was put into service by Mississippi River Fuel Corporation on its 22-in. line at Wilmar, Arkansas. Double-jointing of pipe by the automatic submerged arc welding process was introduced and became popular with pipe line constructors. Crude transportation developments in the post-war period included Magnolia's Corsicana Patoka 20-in., followed by the Platte 20-in. outlet from Wyoming, Sinclair's Cushing-Chicago line, and the 750-mile Trans Mountain 24-in. in Western Canada. The 1300-mile, 26 and 30-in. Texas-Illinois gas line and the 1800-mile, 30-in. Transcontinental gas line from Texas to New York were among the first to bring a new concept to pipe line communications with their long-distance microwave systems. Thousands of miles have since been put into operation.



SPECIFICATIONS

Specific gravity, A.S.T.M. D-71	1.40-1.50
Softening point, A.S.T.M. D-36	190-200°F.
Penetration, A.S.T.M. D-5 100 g., 5 sec., 77°F.	2-6
Ash, A.S.T.M. D-271	20-25%
Sag test, 7 hrs.	no sag at 140°F.
Cold cracking test, 5 hrs.	no cracking or disbonding at 0°F.
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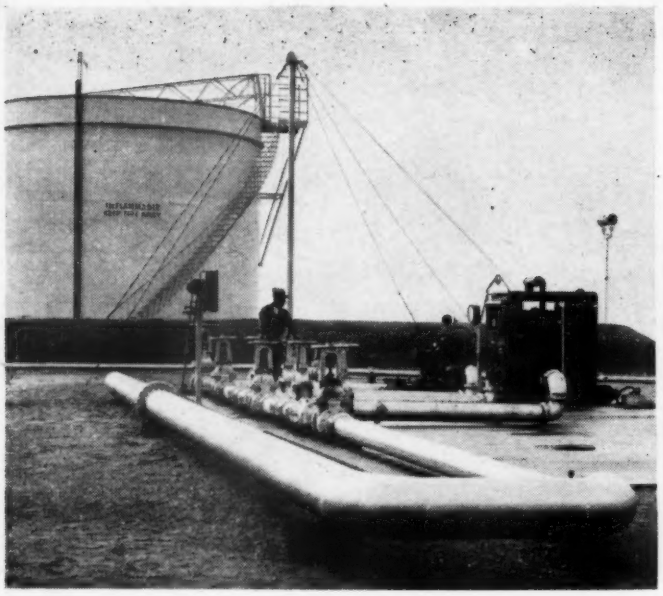

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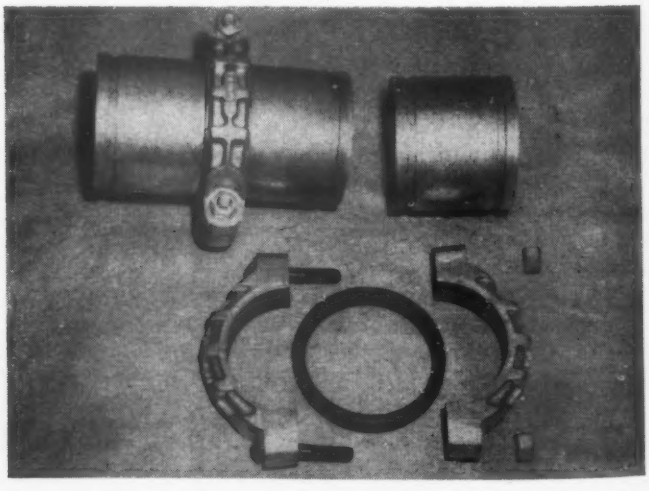
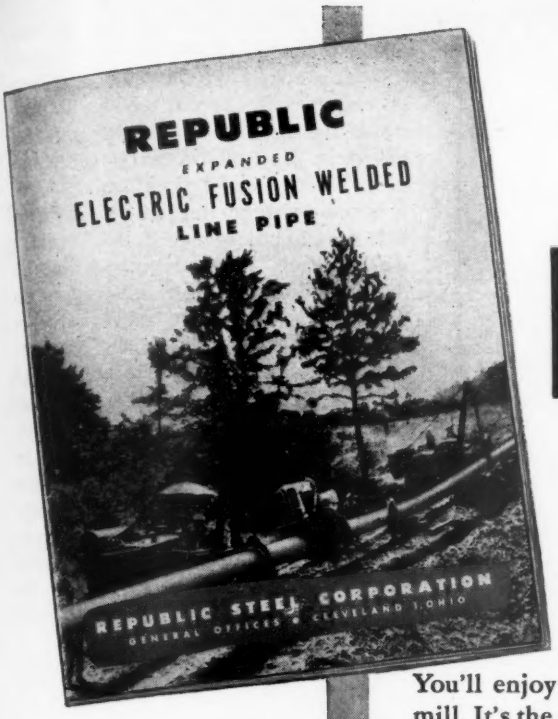
Each unit of equipment is carefully planned and checked at the laboratory site. Pumps and motors for use on fuel lines are designed for mobility, as are complete "dispensing stations" for placement at strategic locations on the lines once they are laid in place. * * *



Grooved type coupling used on portable pipe lines. Exploded view at bottom shows component parts, top view shows assembled coupling.



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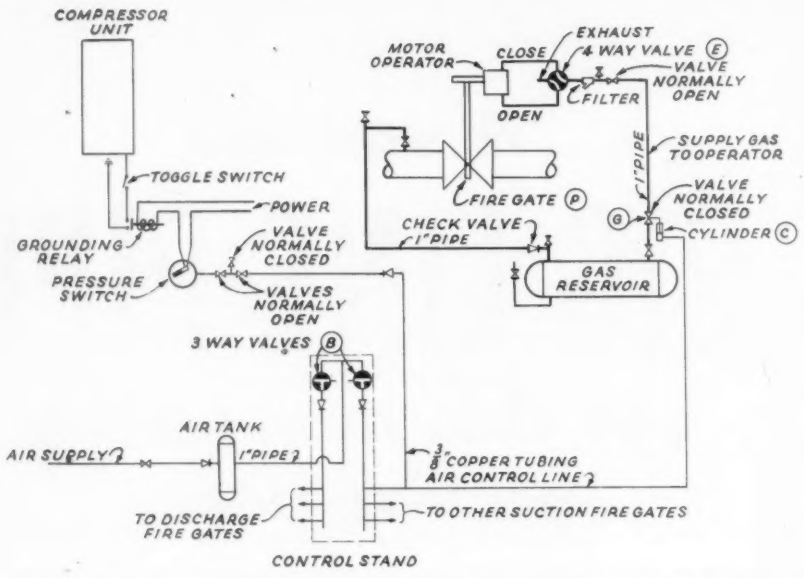

FIG. 1. A gas compressor station emergency shutdown system using gas motor valve operators and a pneumatic control system.

The trend is toward wider usage of power operated, remotely controlled valves; here's the first of two articles giving a complete discussion to . . .

Remote Valve Operators

BURT OLIVE, JR. and M. M. HELLER

NEARLY all of the major gas transmission companies are now using some power operated and remotely controlled valves, and the trend is toward still wider usage of valve operators along with manual, remote, or automatic control systems.

As pipe line valves have become increasingly larger, it has been found advisable to use power operation to reduce the time and number of men required for valve operation. As many as 600 or more turns of the handwheel are necessary to close certain 30-in. pipe line gate valves. To start opening these same valves with a 1000 psi pressure differential across the valve requires a torque of 300 ft-lb or more at the handwheel shaft.

By-passing large size valves with smaller size valves aids in opening but does not solve the problem of closing quickly in event of an emergency. The larger valves are, therefore, powered for easier, faster operation even though remote control or automatic operation may not be required.

In addition to being power operated, various valve installations are often equipped with automatic or remote controls. Pipe line valves, especially river header valves and valves not easily accessible, and compressor station suction, discharge, and blow-off valves are usually thus equipped. Telephone wire circuits, and in a few cases, diaphragm gas regulators and radio are often used to remotely control valves.

Practically all the larger gas compressor stations have some type of emergency shut-down system in which remote control valves play a major part. After considering the consequences of a possible fire or blowout in a large compressor station, wide usage of an emergency shut-down system is easily understood. Quick closure of valves in pipe line entering the station and venting of station piping gas at a safe distance from the plant, serves to prevent pipe lines from feeding a break inside the station. In addition to safeguarding life and property, reduction in insurance rates is significant.

Most gas pipe line companies provide several emergency stations located within each compressor station at points easily accessible in event of an emergency. Opening a small valve or valves, or closing a switch sets the emergency system in operation; and as a result, valves in all gas pipe lines entering the station are closed quickly. Station bypass valves may also be equipped to bypass the station automatically and thereby maintain pipe line operation. Blowdown valves may be equipped to open and vent all station piping, engine fuel valves may be closed and engine ignition interrupted, shutting down engines.

In addition to emergency manual stations, some systems employ automatic devices to actuate the emergency system if a break occurs in station piping. A central control panel may be employed to remotely control all valves in the emergency system. Here, indicator lights may be provided to show at a glance the position (open or closed) of each remotely controlled valve, and serve as a check on their operation.

Remote and Automatic Compressor Station Shutdown Systems

An emergency shutdown system used by one gas transmission company is shown in Fig. 1. It accomplishes the closing of the station valves and the shutdown of the engines by hand operating two small valves.

Two such valves are located at each of several locations about the plant. Gas from the pipe line, at pipe line pressure, is trapped in a reservoir that acts as a supply for the power medium for the valve operators. For a particular operation of the emergency system, the valve operators are thus independent of the pipe line. Control of the flow of gas from the reservoir to the operator is by starting air.

For automatic shutdown, the two 3-way valves at a control station are opened. One of these valves controls station suction valves and the other controls station discharge valves. Control air then passes from air tanks through 3-way valve (B) to cylinder (C) which opens valve (G), admitting supply gas from reservoir to motor operator through 4-way valve (E). Position of 4-way valve (E) is charged for reopening fire gate.

Opening valve (B) also admits control air to a pressure switch causing its contact to close. As a result, ground-

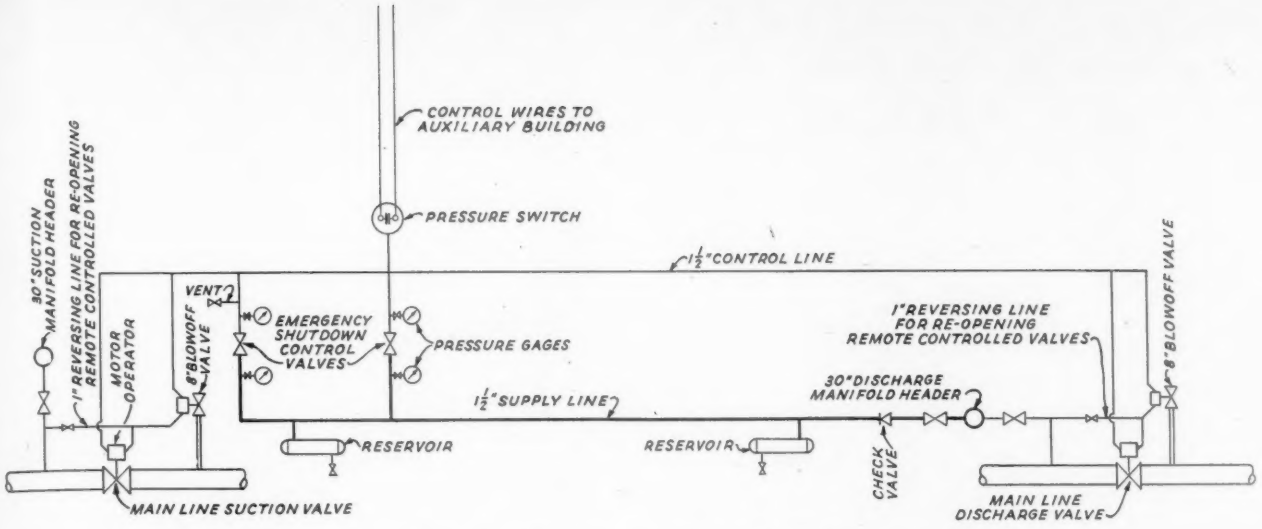

FIG. 2. An emergency shutdown system using gas motor valve operators and remote manual control.

The Authors

Olive Heller

Burt Olive, Jr., is an engineer for United Gas Pipe Line Company. He is a graduate of Louisiana Polytechnic Institute with a degree in mechanical engineering. Olive has been with the company since 1949.

M. M. Heller has participated in various engineering activities of United Gas for the past 17 years. He has a B.S. degree in mechanical engineering from the University of North Dakota and a M.S. from the University of Texas.

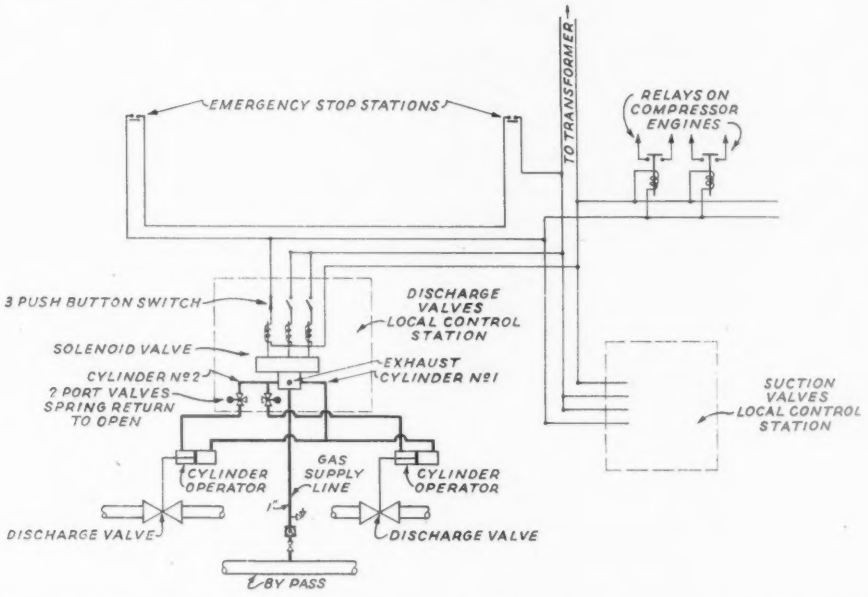

FIG. 3. An emergency shutdown system using gas driven valve operators and an electric control system.

ing relays are energized and engine magnetos are grounded, stopping engines.

A second remote control system shown in Fig. 2 also uses natural gas from the pipe line as the power medium. By opening a valve at a control station, main line suction and discharge valves are closed, blowoff valves are opened to vent all station piping, electrical power is shut off from compressor building, and engine ignition is cut off, stopping all engines.

Supply gas is taken from the discharge manifold header and is trapped in two reservoirs. A check valve prevents reservoir gas from flowing back to the discharge header. Opening a 2-in. valve at a control station allows supply gas to flow through it and through the control line to all gas motor operators. This gas also flows to a pressure switch that closes and energizes trip coils which open circuit breakers in the main switch boards, breaking all electrical circuits to the compressor building. Engines stop from lack of ignition. For reopening and reclosing control valves, another small line connects all motor operators to the pipe line.

The diagram shown in Fig. 3 shows a compressor station emergency shutdown system which uses gas driven cylinder operators and electric controls. The electric control system is energized at all times. Power failure or breaking of the circuit at an emergency stop station causes automatic closure of station suction and discharge valves and shuts down engines. Push button stations are located near valve installations for local operation.

Some gas companies employ air to control and drive valve operators. This system is illustrated in Fig. 4.

Several control stations at various locations within the plant are connected in series. Opening a valve at either of these stations vents control air and causes engines to stop, fire gate valves to close, and relief valves to open. For example, suppose that control valve (A) is opened. Air supply to the system is blocked and control air is vented through it to atmosphere. Pressure switch (B) cuts off engine ignition. Check valve (C) prevents air trapped in reservoir from passing back into the control system. Loss of pressure on diaphragm valve (D) positions it so that air passes from the reservoir to a 4-way valve (E), and to one side of the valve operator piston forcing the piston to move and close the valve.

To blow down station piping, a relief valve which incorporates a manual blowdown feature is used. Opening a small valve on this relief valve releases

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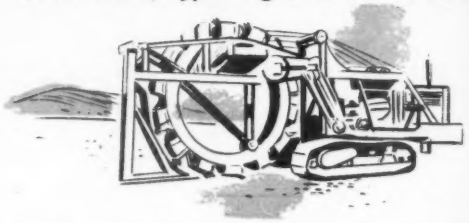

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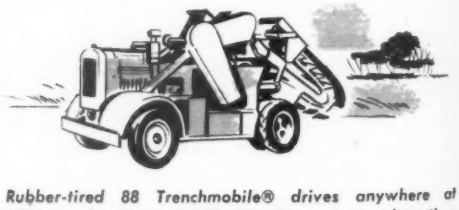

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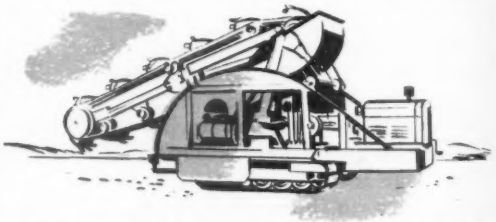

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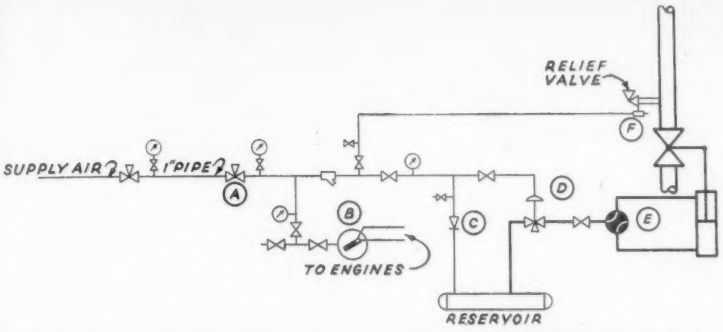

FIG. 4. An emergency shutdown system using air driven cylinder valve operators and air control system.

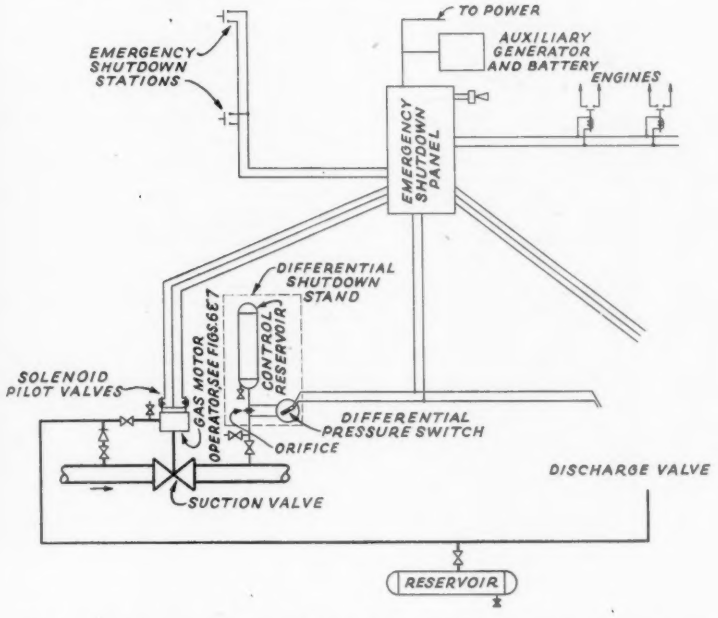

FIG. 5. An emergency shutdown system using gas motor valve operators and an electric control system.

the pressure on a piston and allows the relief valve to open. Control air is connected to relay valve (F) on the relief valve. When control valve (A) is opened, loss of pressure actuates relay valve (F), which in turn opens relief valve and blows down station piping.

Another gas transmission company uses a compressor station emergency shutdown system that employs both cylinder valve operators and high speed rotary vane type operators, gas driven and electrically controlled. Supply gas is held trapped in a reservoir which is fed from the main line through a regulator which reduces the pressure to 200 psig. Valve operators are located on station suction and discharge valves and are controlled by solenoids.

All emergency system control circuits are powered by a 32 v battery installation located in the auxiliary building. This battery fed circuit also controls the emergency engine shutdown circuit and supplies power for the emergency lighting circuit. Push button stations are provided at various locations within the plant to actuate the emergency system.

Because of the large inrush current requirements of solenoid valves, a sequence timer energizes each solenoid at 5 second intervals and locks in the holding current. Transfer switches and test lights are provided for the individual testing of circuits. Each valve operator is also provided with a manual bypass for either opening or closing it locally.

Several companies are using automatic control systems to shutdown stations or close one or more main line valves automatically in event of a line break. A gas reservoir is connected to the mainline by means of an orifice. During normal operation reservoir pressure and mainline pressure are essentially the same, but in event of a blowout, mainline pressure drops suddenly, while reservoir pressure drop is retarded by the orifice. A pilot valve or differential pressure switch senses this differential pressure across the orifice and causes closure of a valve or sets an emergency system in operation, when the differential has reached a set value. A pilot valve or switch is usually set to actuate when the rate of fall in pipe line pressure is approximately 25 to 30 psi per minute. This setting rate must be high enough so that normal operating procedures will not cause actuation.

An emergency shutdown system used by one gas transmission company for its larger compressor stations is illustrated in Fig. 5. Station suction and discharge valves are operated by high speed rotary vane type gas motor operators controlled electrically from an emergency shutdown panel in the auxiliary building. A single gas reservoir used to power valve motor operators is connected to all pipe lines entering the station by means of check valves that prevent gas from flowing from the reservoir back into pipelines.

When the emergency shutdown system goes into operation, an alarm trumpet is sounded, station suction and discharge valves close, and engines are stopped by relays which ground engine magnetos. A timing relay keeps emergency shutdown circuits energized until all devices have operated.

This emergency system may be actuated by either of two ways. A button may be pushed at one of the emergency stations or the system may be actuated automatically in the event of a pipe failure by a differential pressure switch across an orifice as described in the previous paragraph. Each station suction and discharge header is equipped with one of these differential pressure switches.

In event of failure of station electrical power, a small auxiliary generator starts automatically and provides sufficient power to actuate the emergency system.

The station bypass valve is motor operated also but it does not operate automatically in the emergency shutdown system. With a check valve in this bypass line, the bypass valve could also be made to open automatically for emergency. Thus, when the discharge pressure fell to a value below that of the suction pressure the bypass line would open automatically.

All motor operated valves may be opened or closed individually by push buttons on the emergency shutdown panel, or be operated locally by knobs on solenoid pilot valves on the motor operators. Indicator lights are used on emergency shutdown panels at a few stations to show positions (open or closed) of all motor operated valves.

This emergency shutdown system is designed so that circuits can be easily checked frequently and periodically, without shutting down the station. Dif-

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ferential shutdown stand operation may be checked by shutting off the valve connecting it to the header and bleeding the connecting line, thereby simulating a header failure.

Other Uses of Motor Operators

Gas turbine stations and electric powered centrifugal stations, and now certain gas engine driven reciprocating stations, completely start up and shut down automatically when given a signal from a station operator or dispatcher. Time is saved and the number of skilled operators is reduced by use of remote control equipment. Here again, valve operators play a vital part in operating valves in the proper sequence to start up and shut down a station. An emergency shutdown system may be incorporated in this automatic starting and stopping equipment to initiate shutdown operations as well as control emergency equipment previously mentioned.

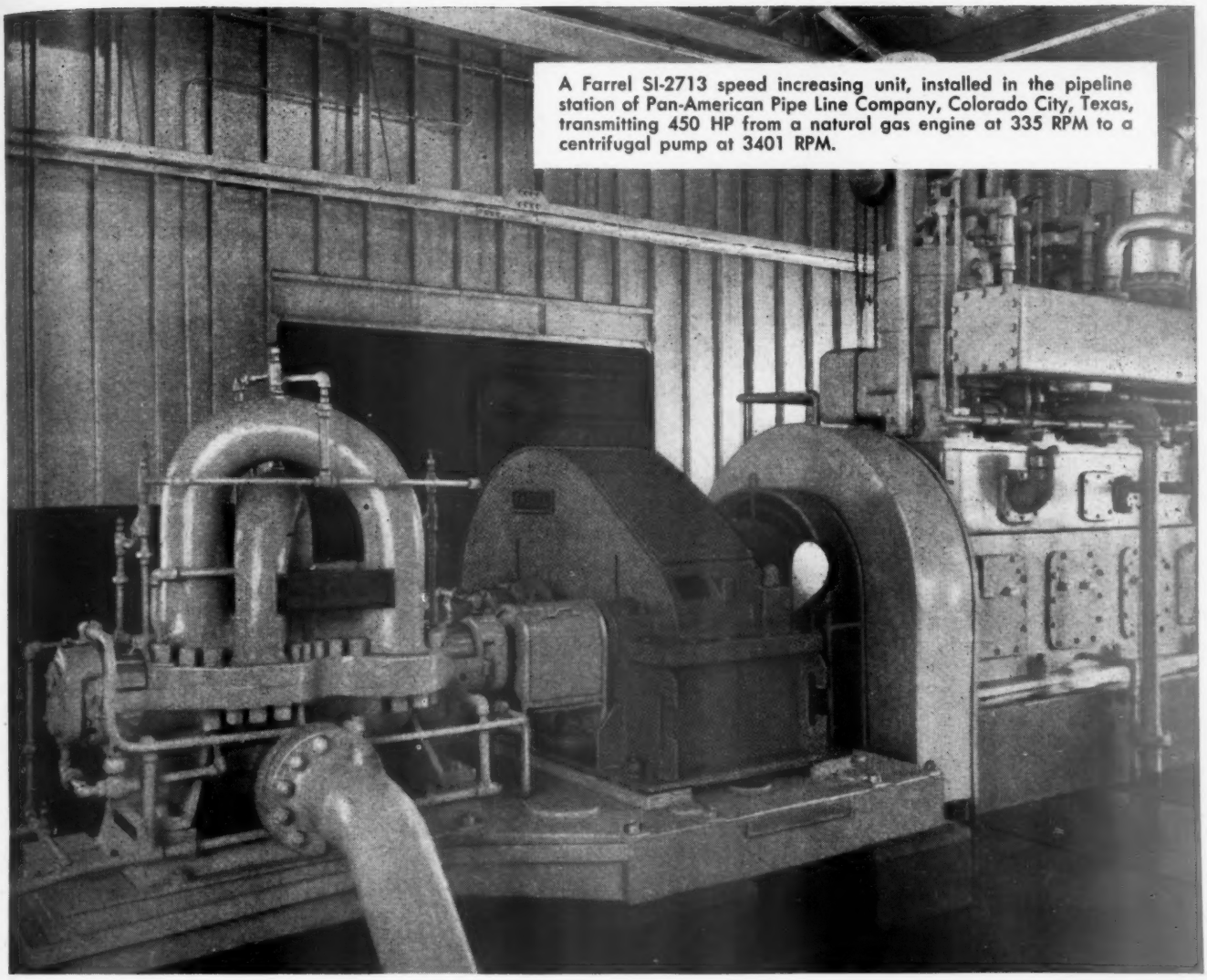
Valve operators are often used to improve the accuracy of gas measurement by automatically opening and closing meter tubes in a measuring station as the station load varies.

In one case of a two tube station, a plug valve in the first meter tube is equipped with a 90 deg turning vane operator. Operator supply gas is taken from the upstream header and passes to the operator through a diaphragm 4-way valve which controls direction of vane movement.

The operation of such a station is as follows: When a differential pressure across the orifice of the meter tube using the combination meter-controller reaches the controller's high set point, the controller output pressure of approximately 15 psi collapses to zero. This output is connected to the top of the diaphragm actuated 4-way valve. As the output pressure on top of the diaphragm collapses, a spring returns the 4-way valve stem to the position required to admit gas to the side of the valve operator that causes the valve to open, putting the first meter tube in service. The other side of the operator is exhausted through the 4-way valve.

When the differential pressure across both meter tube orifices falls to the controller's low set point, the controller output pressure suddenly builds up to 15 lb. This pressure on top of the 4-way valve diaphragm moves its stem so as to reverse gas flow to the valve operator which then closes off the valve and puts the first meter tube out of service.

Part 2 of this discussion on remote valve operators will discuss the mediums used to drive and control valve operators. This second article is scheduled to appear in next month's issue of The Petroleum Engineer.



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Centrifugal Compressors as Gathering Units

On Natural Gas Lines?

Surprisingly enough, the centrifugal compressor is readily adaptable; limitations may result from lack of flexibility in the prime mover

HAROLD WOODHOUSE

ALTHOUGH the centrifugal compressor has not as yet been noticeably used as a gathering unit in gas pipe line systems, there is considerable interest in its possibilities in this direction.

There are several reasons for the lack of use of centrifugals in this apparently promising field of application.

The first, and probably most important, is the absence of a specifically designed, high speed, moderately priced machine for the job.

The second reason, from which stems the lack of action by the centrifugal compressor manufacturers, is the tremendous variation in the pressure and flow conditions applicable to gathering units. As this is coupled with only a moderate overall volume of business, the manufacturers probably feel that it would result in a series of non-profitable, one unit, custom made orders.

A third reason is that the predominate personnel connected with the gas pipe line industry, both with respect to the compressor manufacturers and the pipe line operating personnel, are trained with regard to reciprocating compressor use. They view the centrifugal compressor as a very low pressure ratio, large capacity machine with a somewhat inflexible range of operation.

There are only one or two companies in the entire country with any extensive experience in building both reciprocating and centrifugal compressors for the gas pipe line industry.

Purpose of this article is to show that there is a surprising amount of flexibility to the centrifugal compressor and that, for a gathering unit, the limitations may spring entirely from the lack of flexibility in speed and horsepower of the prime mover.

Primary Considerations

In considering the design of a centrifugal gathering unit the inclusion of certain desirable characteristics is immediately obvious, as follows:

(1) The impeller should be capable of high tip speed in order to secure a maximum pressure rise.

(2) As the maximum pressure ratio corresponding to maximum tip speed may not be required initially it is desirable that the centrifugal be capable of being speeded up to the maximum tip speed permissible for the type of impeller construction being used without making the bearing surface rubbing speed too high or running into the shaft critical speed range.

(3) For minimum cost it is desirable that the unit be single stage. Low cost would also indicate that the impeller be overhung to eliminate one high pressure seal and facilitate the elimination of a horizontal split casing — a very desirable characteristic for high pressure use.

The single stage, overhung impeller, non-split volute casing is the basic design now generally in use for gas pipe line centrifugal compressor stations and has evolved from earlier multistage, horizontally split conventional units.

The Author

Harold W. Woodhouse is chief engineer of Dean Hill Pump Company, and during this period has acted as consultant for Cooper-Bessemer Corporation in supervising design of a line of pipe line centrifugal compressors.

He was educated in England where he was associated with Fraser and Chalmers Ltd. He later joined in the engineering department of DeLaval Steam Turbine Company, Trenton, New Jersey, and later became engineer in charge of development of the radial flow turbine wheels and mixed flow compressor impellers.

From 1945 to 1947 he was director of engineering for the Stratos division of Fairchild E and A Corporation, becoming general manager and chief engineer of Power Generators Ltd. in 1947. He resigned his position in 1950 to accept his present one.

Limitations

The centrifugal compressor is ordinarily a large capacity machine and there are certain natural limitations to the minimum flow that it can handle economically. These limitations are the result of several inter-dependent factors, which will be considered in their turn.

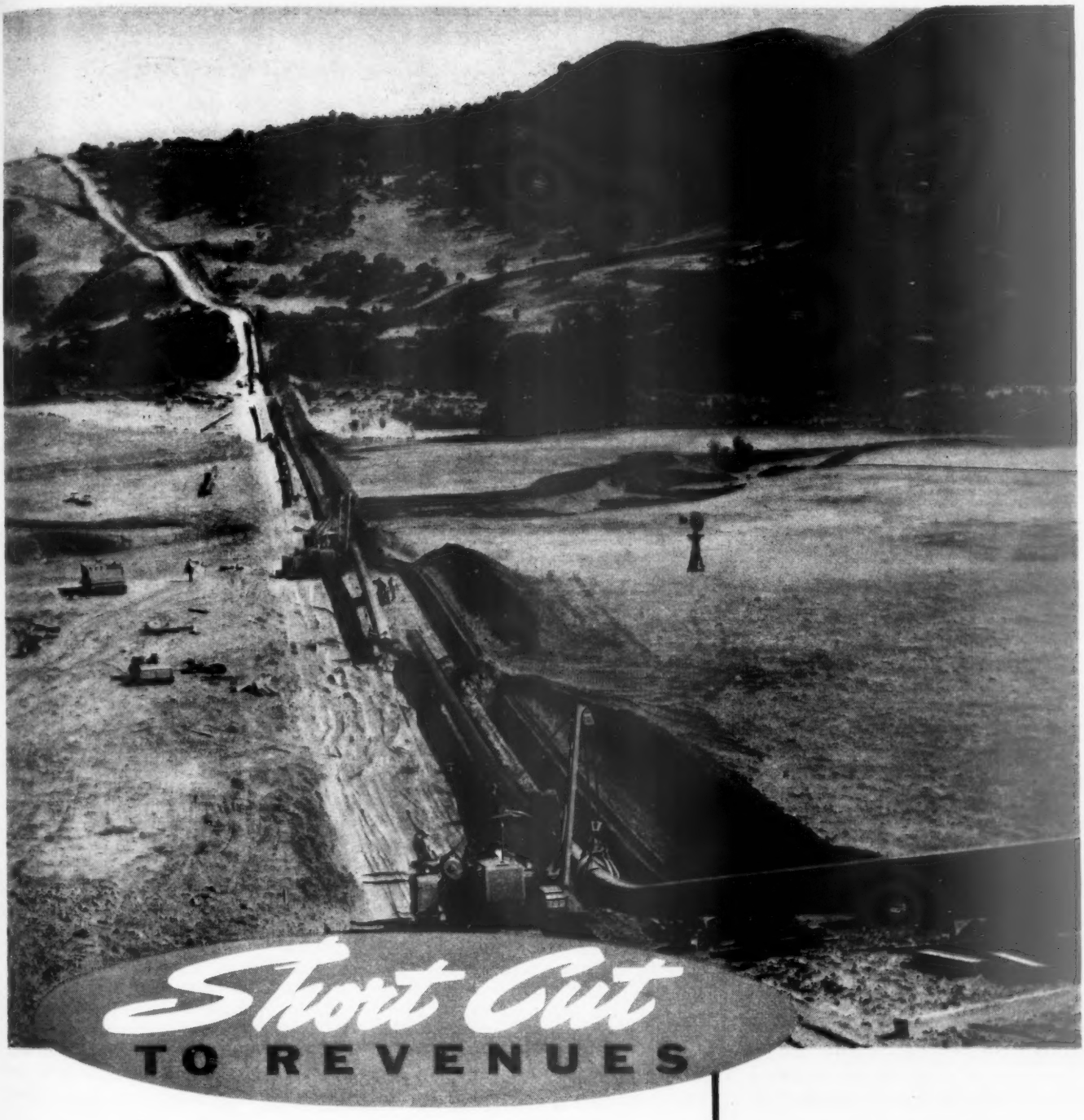
Tip Speed. Maximum tip speed is dependent on the method of construction of the impeller. According to the type of construction, the maximum might be anywhere from 300 ft per sec for cast bronze or a low grade of brazed fabricated design to 1600 ft per sec. for one with vanes machined from a solid steel or aluminum forging.

In approximately an ascending order of safe tip speed, the following is a guide to the various methods of making impellers:

(a) Cast iron
(b) Cast bronze
(c) Brazed fabricated bronze design
(d) Cast steel
(e) All steel fabrication with riveted plate vanes
(f) Cast aluminum
(g) All steel fabricated with milled and riveted vanes
(h) Forged steel paddle type vanes
(j) Steel or aluminum forgings with vanes machine generated from solid forging.

These various types are illustrated

EXCLUSIVE



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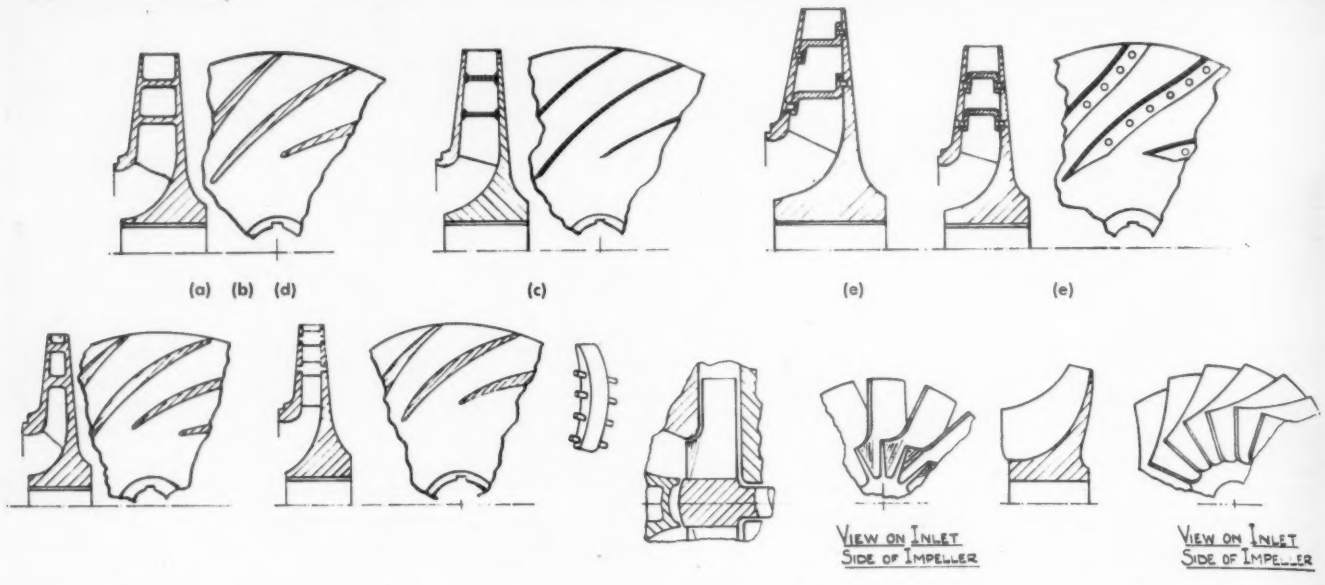

Chart 1

(Chart 1) using the same reference letters.

Types (a) and (b) are standard construction for centrifugal pumps but are of little use for centrifugal blowers because of their low safe rotative speeds.

Type (c) is used for some inexpensive blowers with low pressure ratio such as Freon refrigeration units of small commercial centrifugal sizes — 50 to 200 tons of refrigeration. They should not be used for more than about 350 ft per sec.

Type (d) has been used extensively for the large flow centrifugal compressors in gas pipe line compressor stations. They are very expensive; they cannot be made light because of steel casting difficulties and they require a great deal of hand filing and de-burring to make a reasonably smooth vane passage. In a small capacity impeller the passages would be so narrow it would be impossible to clean them out and it would not even be possible to see well into the passages by any ordinary method.

The cast steel impellers in use have been restricted to about 500 ft per sec, which is too low a maximum for a gathering unit.

It might be mentioned that the centrifugal pump industry uses a great many impellers of special cast materials such as nickel, cupro-nickel, and stainless steel that fit in this or somewhat higher speed range but their cost is prohibitive for the application under consideration.

Type (e) is the standard construction for industrial blowers, either single or multi-stage. Their recommended maximum normal speed is in the neighborhood of 750 ft per sec. The vanes are pressed to either a "U" or "Z" cross-section and are riveted to forged and machined side disks. Vane bending stresses and rivet shear stresses limit the speed.

Type (f) is commonly used for diesel engine centrifugal superchargers and is used in a size range — up to 20 in. or 24 in. diameter — which could be a desirable size for a gathering unit. Their normal running speed is around 600-700 ft per sec with overspeeds permissible up to 1000 ft per sec.

Type (g) consists of two steel side disks with solid, milled vanes riveted between the disks. This design is used when the impeller is narrow, i. e., the inlet and discharge widths are small, then the bending stresses in the vanes and the load on the disks to carry the vane are both within reasonable limits. As we are concerned with the small flows that a gathering unit would normally handle, the width of the vanes will be the minimum considered practical for manufacturing. Such construction can be used for 1000-1200 ft per second.

Type (h) has been used commercially for many years. The impeller is made from a solid steel forging with the vanes milled to the shape of flat paddles. After machining, the inlet edges of the vanes are bent to give the correct inlet edge angles. No side disks are used. This construction has been used up to about 1200 ft/per sec. There is no streamlining of the flow path so this fact combined with the high tip speed results in a low efficiency. This type of impeller is more expensive to produce because of the high forging cost and the large amount of vane machining required.

Type (j) has been used exclusively for those applications requiring extremely high tip speeds such as aircraft reciprocating engine gear-driven supercharger impellers, aircraft reciprocating engine exhaust gas turbosuperchargers, aircraft cabin pressurizing and air condition air-cycle turbocompressors, aircraft turboprop and jet engines using a centrifugal compressor element.

These impellers are quite expensive to make as solid aluminum or steel forgings are used and they are subjected to costly vane generating operations. Such impellers, even in aluminum, have been subjected to tests at 1900 ft/per sec.

It will be noted that this type of impeller has its applications entirely in the aircraft field and secondly that these applications are, in the main part, for military aircraft, where cost is a negligible or minor matter. Further, the life expectancy for aircraft is far less than is required for industrial use.

Construction Possibilities

In reviewing the various possible methods of impeller construction the logical choice for moderate cost coupled with relatively high tip speed possibilities is Type (g). Being an all-fabricated design its dimensions and vane angles may be readily changed to suit an individual application that would not be the case if it were cast. This is highly important where the orders would probably be only one or two of a kind exactly alike, and at the same time.

Although an aluminum impeller would do the job of pumping the gas quite satisfactorily, it could, unfortunately, by no means absorb the same amount of punishment as steel—such as the shock resulting from, for in-

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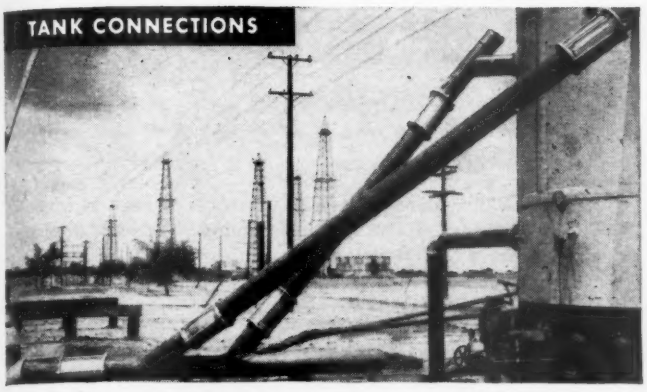

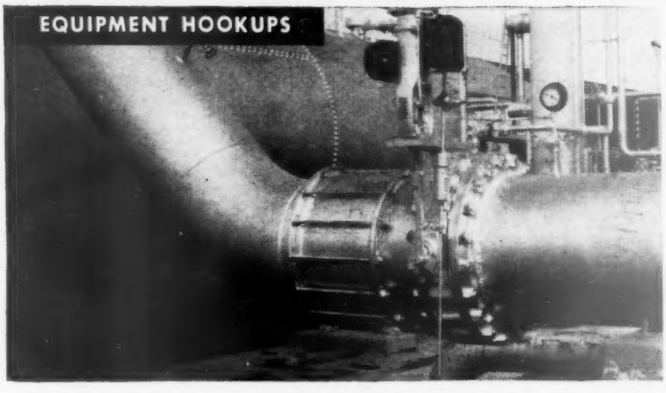

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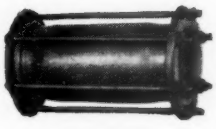
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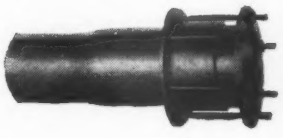
Long Sleeve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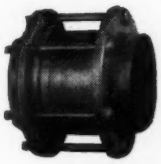
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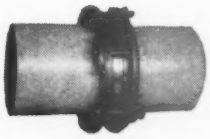
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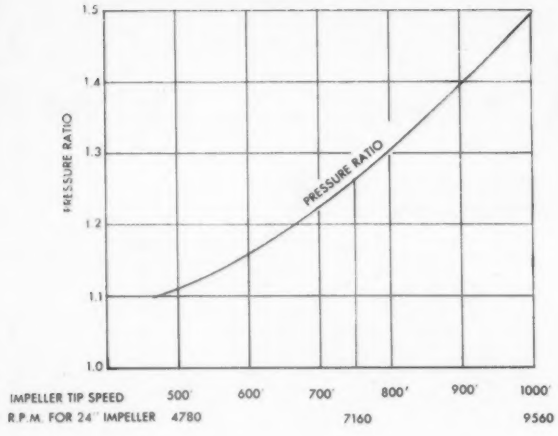

FIG. 1. Pressure ratio versus impeller tip speed and rpm.

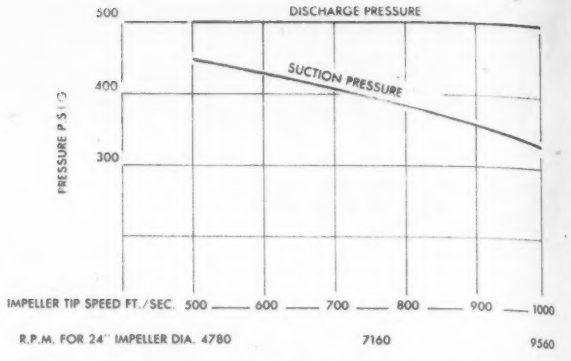

FIG. 2. Minimum suction pressures at various impeller tip speeds and rpm for maintaining a constant discharge pressure of 500 psig.

stance, a piece of 2 by 4-in. wood, or workman's tool left in the pipe line when it was welded, getting into the impeller inlet and going through the impeller. Such things have happened with steel impellers and, beyond a momentary noise and vibration, the unit has continued to function quite normally.

This selection permits the consideration of 1000 ft/per sec as the top operating speed. As we will not be concerned with especially low tip speeds, since the pressure rise produced becomes quite negligible, the minimum that will be given consideration is 500 ft/per sec.

Impeller Dimensions. These are interdependent in most cases and some trial and error selections are necessary. For instance, the size of the inlet eye must be selected so that the inlet flow velocity is moderate, but the velocity will depend on the volume flow, which is unknown until the design has progressed to some extent. The inlet eye diameter will affect the selection of the outside diameter of the impeller since, for a radial discharge impeller, the outside diameter should be at least twice the inlet vane edge diameter.

In turn, this outside diameter determines the rpm which will affect the size of shaft and bearings necessary to avoid trouble with critical speed.

An inlet eye of 10-in. and an outside diameter of 24-in. are selected. The range of speed to be covered is then fixed as:

For 500 ft/per sec tip speed, rpm = 4780
For 750 ft/per sec tip speed, rpm = 7160
For 1000 ft/per sec tip speed, rpm = 9560

These speeds are well within the limits in common use for small commercial multi-stage centrifugals, many of which run over 12,000 rpm.

The minimum discharge width of the impeller is selected as ⅜-in. After assuming a radial flow velocity, the velocity diagram for the impeller outlet can be made and the mass flow, volume flow and pressure ratio determined by the conditions at the impeller discharge.

Minimum Conditions

With the preceding and other minor assumptions we can proceed to determine the minimum conditions for which the centrifugal gathering unit will be applicable. The calculated results are reproduced in the form of the following curves:

Fig. 1. This shows the pressure ratio that can be obtained for various tip speeds from 500 to 1000 ft per sec. The range is seen to be from, roughly, 1:10 to 1:50. This pressure ratio is that which would be obtained with a typical natural gas. With air or other heavier gas it would be quite a little more. To those unfamiliar with centrifugal compressors it is always puzzling that the head developed is independent of the kind of gas but that the pressure ratio will vary according to the characteristics of the gas being handled.

Fig. 2. Translating the meaning of

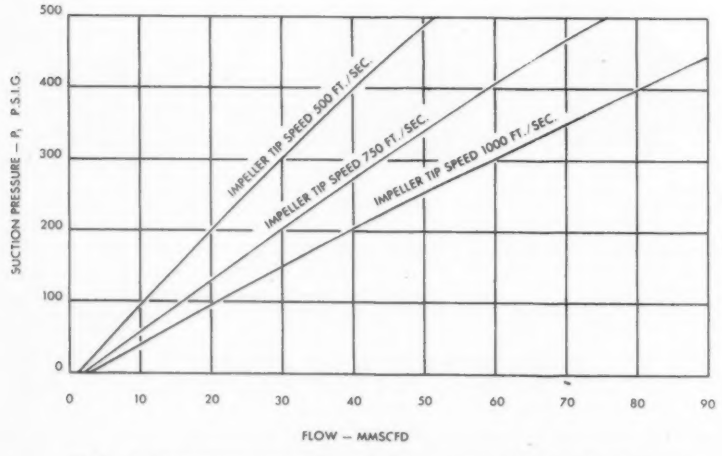

FIG. 3. Minimum capacities of single centrifugal gathering units at various tip speeds.

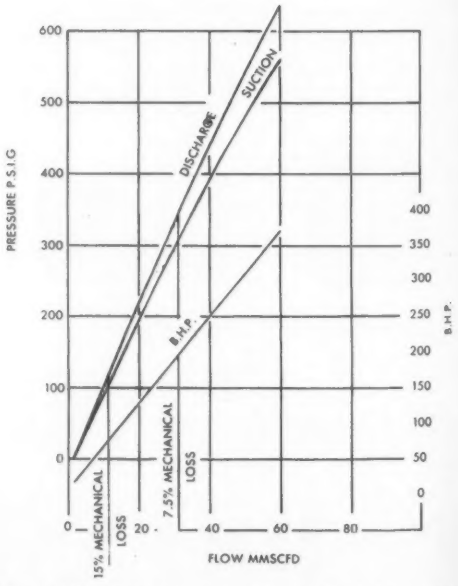

FIG. 4. Discharge pressure, bhp and minimum designed flows for various suction pressures. All for 500 ft/sec.

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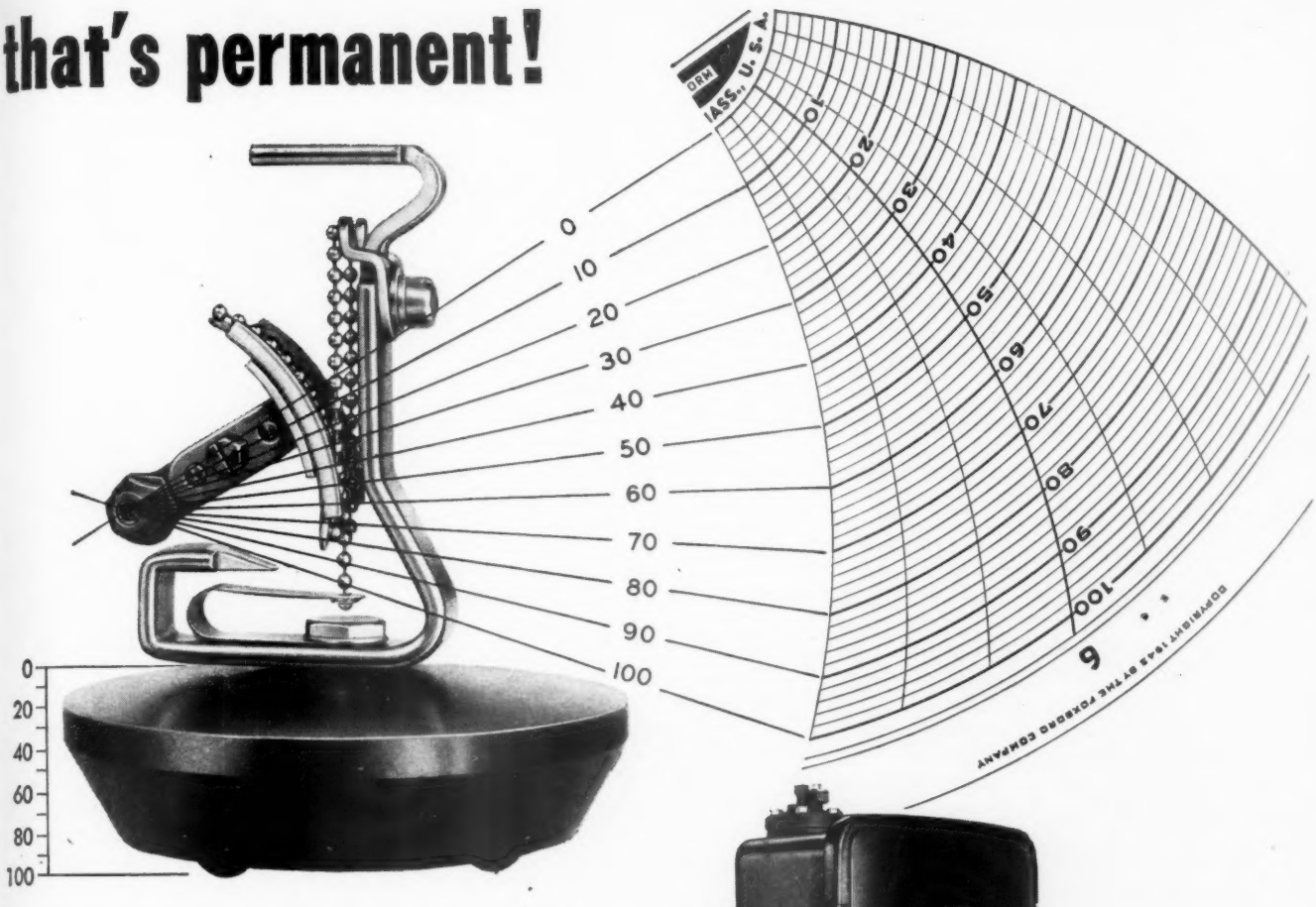

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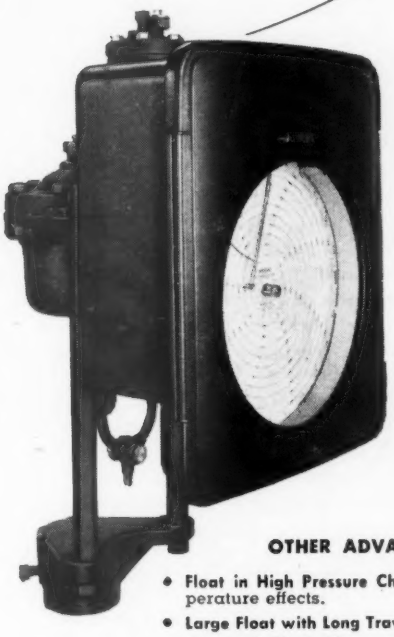

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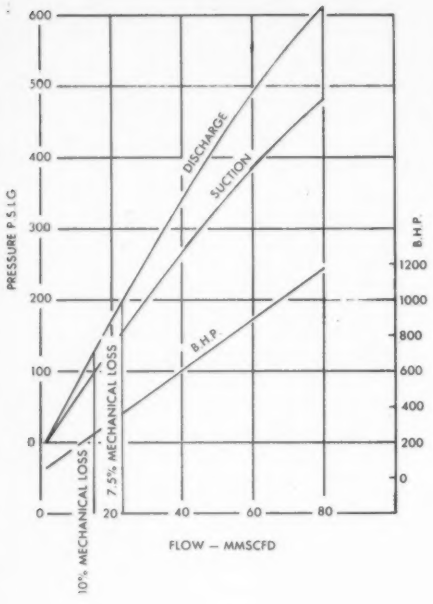

FIG. 5. Discharge pressure, bhp and minimum designed flows for various suction pressures. All for 750 ft/sec.

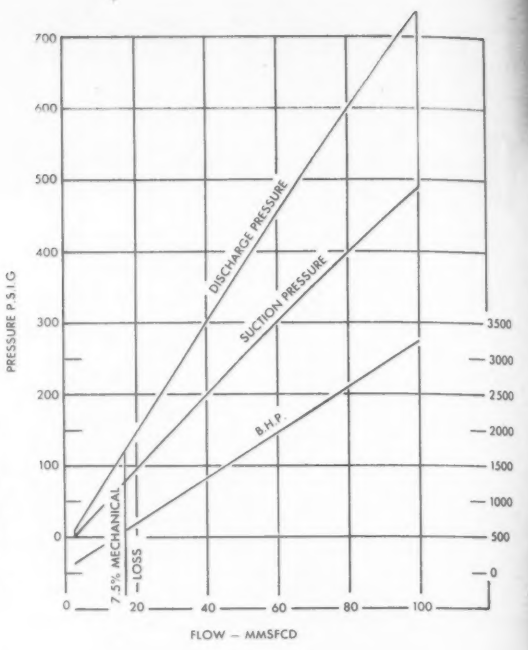

FIG. 6. Discharge pressure, bhp and minimum designed flows for various suction pressures. All for 1000 ft/sec.

the range of pressure ratios as given in Fig. 1 we can show by this curve that if in a particular natural gas application it is required to maintain a discharge line pressure of 500 psig the centrifugal gathering unit could deliver this pressure with an impeller tip speed of 500 ft per sec if the initial suction conditions were 448 psig and could continue to maintain this discharge pressure until the suction pressure had dropped to 330 psig if the impeller were speeded up to 1000 ft per sec.

Fig. 3. Shows that the minimum flow in Mmscfd for which the centrifugal can be designed is dependent on the suction pressure and the tip speed.

It is quite important to note that operation at any point of any one of the three curves — 500, 750, or 1000 ft per sec — of Fig. 3 will give substantially the same efficiency, which is maximum efficiency for the design because the impeller will be operating at the same load coefficient; that is, for any point on any of the curves the impeller is handling the same number of cubic feet of gas for each revolution. Actually, there is a tendency for efficiency to decrease with increase of tip speed due to the greater friction and turbulence losses even though the impeller vane angles will be correct for any of the flow points on any of the curves of Fig. 3. The decline in efficiency at constant load coefficient is not especially noticeable until the tip speed becomes quite high.

Figs. 4, 5, 6. If we maintain the load coefficient constant and calculate the flow in Mmscfd and the bhp for various suction pressures we will obtain the curves of Figs. 4, 5, 6 for speeds of 500, 750, and 1000 ft per sec.

The tremendous range of flow and horsepower which results from changing the suction pressure and tip speed is surprising.

Overall range of flow is from 13 Mmscfd at 500 ft per sec tip speed with atmospheric pressure suction to 66.7 Mmscfd for 500 psig discharge pressure at 1000 ft per sec. It should be particularly noted that these are the minimum flows for the maximum efficiency at the stated tip speeds and suction pressures. If the suction is increased, the minimum flow will be larger, for instance, at 1000 ft per sec with 490 psig suction pressure and a discharge of 735 psig, the minimum flow is 100 Mmscfd. The brake horsepower corresponding to the minimum flows shows an equally tremendous variation.

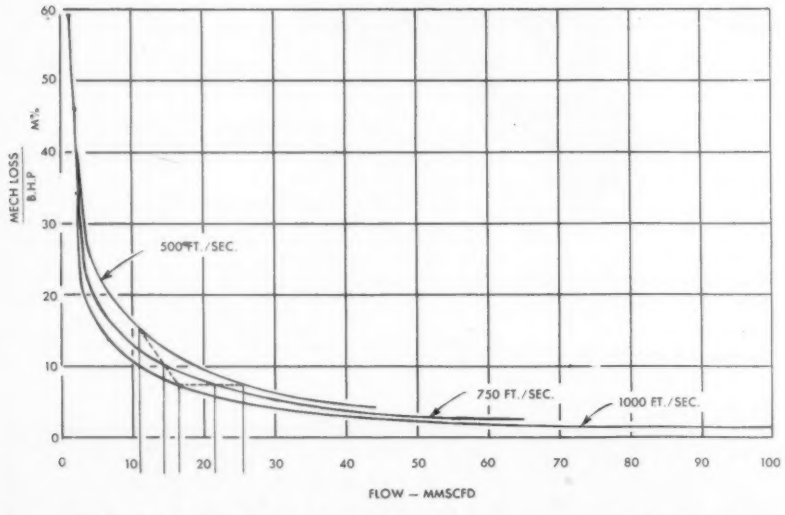

FIG. 7. Anticipated mechanical loss as a percentage of the total bhp input for various impeller tip speeds and flows.

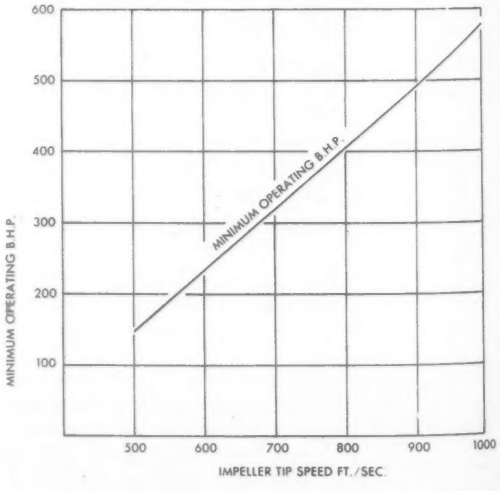

FIG. 8. Minimum operating bhp with an anticipated 7.5% mechanical loss at various tip speeds.

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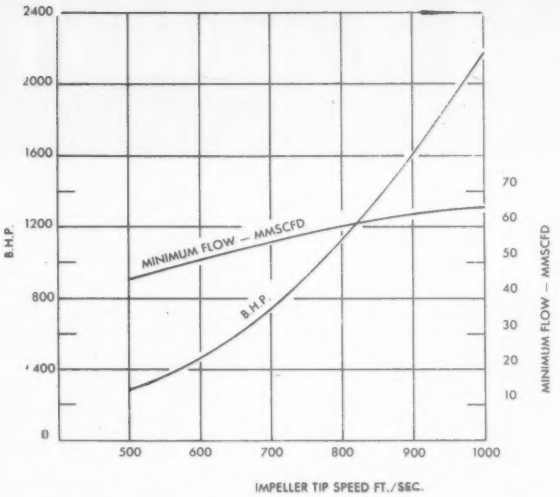


FIG. 9. Bhp and minimum flow for maintaining a constant 500 psig discharge pressure and maximum pressure ratio at various tip speeds as shown by Fig. 2.

From 19.6 bhp at 500 ft per sec with atmospheric pressure suction, the bhp soars to 2175 at 1000 ft per sec and 500 psig discharge pressure.

Fig. 7. If we plot against flow in Mmscfd, the probable mechanical losses as a percentage of the total bhp we see, by reference to Fig. 7, that these losses become an uneconomically large percentage of the required bhp at very low flows as measured in Mmscfd.

If the maximum percentage of mechanical loss is arbitrarily fixed as 7.5, then the minimum desirable operating flows (dotted horizontal line, Fig. 7) are as follows:

1000 ft per sec tip speed, minimum flow = 16.5
750 ft per sec tip speed, minimum flow = 21.5
500 ft per sec tip speed, minimum flow = 25.5

If, because the total horsepower involved is smaller for lower tip speeds, we are prepared to accept a larger percentage of mechanical losses for the lower tip speeds (dotted line, Fig. 7, intersecting curves at 16.5, 15.0, and 11.3 Mmscfd), we could have minimum flows as follows:

1000 ft per sec tip speed with 7.5 per cent mech loss, min flow = 16.5
750 ft per sec tip speed with 10 per cent mech loss, min flow = 15.0
500 ft per sec tip speed with 15 per cent mech loss, min flow = 11.3

Fig. 8. If we plot the brake horsepower for 7.5 per cent mechanical losses for various tip speeds as in Fig. 8, we see that the minimum bhp will range from 148 at 500 ft per sec to 577 at 1000 ft per sec.

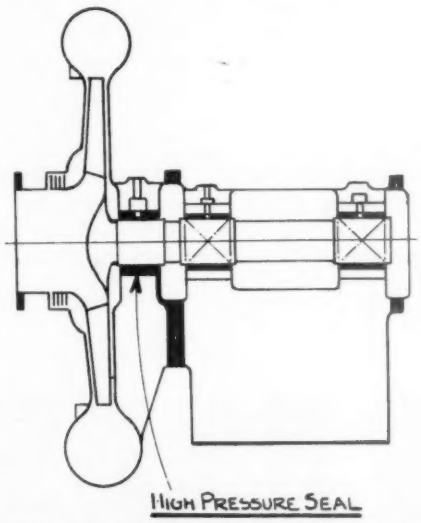


FIG. 10. Diagrammatic arrangement of probable basic design of centrifugal gathering unit.

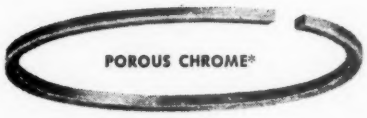
Conclusions

Although every case would have to be considered on its individual merits, the usual circumstances would be where the operator was endeavoring to maintain constant discharge pressure with a declining suction, as illustrated by Fig. 2. With the suction and discharge conditions as shown by Fig. 2, the bhp and Mmscfd would be the minimums given by Fig. 9.

From this, we see that the bhp varies from 285 to 2175 and the flow from 46.0 to 65.8 Mmscfd. For discharge pressures other than 500 psig, these minimums would be different.

It should be carefully noted that all the preceding has been based on designed flow. A centrifugal should normally be capable of delivering 15 per cent more than its designed flow. If, as could conveniently be arranged, the machine is so designed that it can accommodate wider impellers than required for the initial conditions, the flow could be materially increased.

Provided the pressure ratio developed is satisfactory, the problem of flexibility is seen to be one attached to the prime mover rather than the centrifugal compressor since the centrifugal is perfectly adaptable to a wide range of speed, flow, and horsepower. Diagrammatically, the unit would tend to be as shown in Fig. 10. * * *



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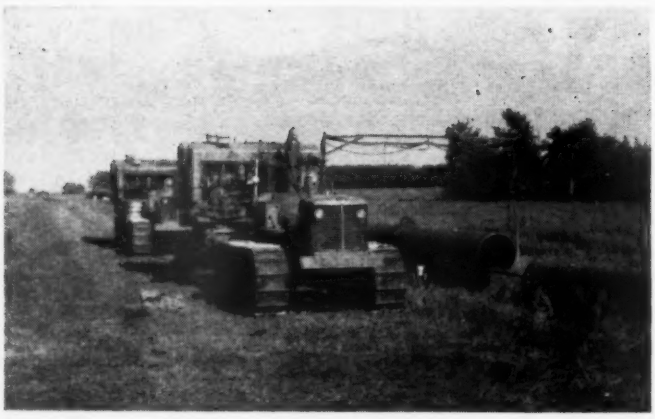

Track mounted pipe gang welding machines, towed by tractors, are needed for mud conditions, in swamps and bogs.

Pipe lined up and skidded by bending crew for shallow slough crossing. In many areas, pipe gangs must work 10-15 miles ahead of ditcher.

Special Report:

Construction Problems in Canada

Terrain, soil conditions, weather are the big headaches; pipeliners have come up with many ingenious innovations in equipment, methods to save time and money, keep work moving ahead

L. O. ROWLAND

ALTHOUGH no inventor has yet claimed the $1,000,000 reward that would fall to him in profits if he could devise an all-purpose vehicle for handling pipe line construction equipment across the muskeg bogs in western Canada, contractors working on Canadian construction in the past 4 years have developed some interesting innovations in pipe-laying technique and in getting across the low spots in the prairies. They have also learned, the hard way, that the prairies are neither as flat nor as dependable for load-bearing as they might appear from a cursory aerial survey.

Coating and wrapping is streamlined operation. Pipe is cradled over ditch during doping, lowered in immediately without further skidding.

Mud has been the persistent enemy of speed in pipe laying in every construction season in nearly all parts of the prairie provinces. Affecting the ditching machines more than any other part of a spread, this condition has led to the extensive use of backhoes in place of rotary ditchers to cross low places where ground water accumulates. One spread on the first Interprovincial construction job in 1950 met the condition by welding extended flanges onto the front ditcher wheels and bolting heavy timbers onto the tracks at the rear, to provide greater distribution of weight, which permitted the ditcher to move over soft ground that it could not traverse with its conventional wheel and track equipment.

On the Trans Mountain construction in the summers of 1952 and 1953, the common solution in muskeg country was to riprap ahead of the ditcher, in the style of the old-fashioned corduroy roads that were a feature of motor travel in many areas in the early years of this century. Availability of light timber along the right-of-way made this attack on the mud and muskeg the most economical solution, as the same riprap could be used for the rest of the equipment following the ditcher. In particularly soft spots and bad holes in the ground, matting of 4 by 8 or 4 by 10 timbers was laid down, and general use of tow-tractors was made to help the heavier machines get across without bogging down under their own weight.

EXCLUSIVE

Stringing and Access Roads

Pipe stringing has been a constant problem in the bogs and swamps of the prairies. In both Manitoba and Saskatchewan, long stretches of open water over the surface in nearly every season have made it necessary to load as few as 5 joints of 24-in. pipe on a stringing truck and to attach 2 tow-tractors to swing the long trucks around the sharp right-angle corners of the country trails and through mud holes as much as 4-ft deep. As many as 12 joints could be carried on some of the same big, rugged trucks in dry weather.

The access problem presented in the prairies by the absence of hard-surfaced roads, is illustrated by the fact that at one point in central Manitoba the trucks had to travel nearly 25

The reliable way to control your pipe line— UNION Centralized Transport Control

When you use Union Centralized Transport Control on your pipe line you have reliable control of the complete system at your finger tips. Each of the many different operations can be quickly accomplished by merely positioning a switch in the central dispatching office. And conditions on the line are clearly indicated on the control panel.

Union Centralized Transport Control is simple in operation and utilizes rugged equipment that has been thoroughly proved. It stays on the job without constant attention by trained electronic experts. Control equipment is mounted behind the panels in convenient, plug-connected units that will operate for years with a *minimum* of maintenance.

This system is a practical adaptation of C.T.C. (Centralized Traffic Control) which for more than 25 years has controlled the intricate and extensive movements of railroad trains the world over. Working on exactly the same principle, Centralized Transport Control will bring your pipe line closer to complete economy and efficiency of operation.

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Please send me your new booklet which describes the many advantages of Union Centralized Transport Control for Pipe Lines.

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Right-of-way is riprapped with locally-cut timber to provide support for crossing of swampy or soft ground areas.

Typical section of muskeg region with water-filled ditch. Pipe is made up along "hard" area of right-of-way and pushed across.

miles in parallel lines to reach a location less than 3 miles from the unloading point, which was actually within sight of the right-of-way.

A different solution in the Rocky Mountains during the Trans Mountain construction was to provide access through the heavy timber along the right-of-way by cutting shoo-flies up the steep slope of the mountainous terrain, then hauling the stringing trucks up with tow-tractors. The shoo-flies were cut at intervals of about a mile to a mile and a half, as the right-of-way in most places was too steeply undulating to permit the long stringing trucks to negotiate the crests and dips.

In Manitoba, when the going got too tough, this summer, the pipe gang trucks were replaced by track-mounted lorries towed by light tractors. Ordinary tire chains were helpless in the sticky gumbo mud that characterizes the prairie soil in extremely wet weather.

Pipe Coating

Coating and wrapping in western Canada has been streamlined, with the pipe being lowered in directly behind the dope gang, which coats and wraps over the ditch to avoid the extra time, expense, and hazard of skidding the pipe a second time. The only places where skidding has had to be resorted to have been where the dope gang got ahead of the ditch or where long bogs and swamps made it necessary to make up a pipe section and push it across. This latter condition prevailed in the foothills portion of the Trans Mountain line, where the length of sections which had to be pushed across muskeg or open swamp amounted to as much as four continuous miles.

Introduced for the first time in Canada last year, on the Saskatoon city gas distribution system, was the yard coating machine developed by Crose-Curran, Ltd., which rotates the pipe as it is fed through, instead of rotating itself around the pipe. This machine, which was set up in Saskatoon at the unloading depot, was able to make maximum footage of 6 miles per day of ¾-in. house service line pipe and 4 miles per day of larger diameter up to 10-in. A good average was 15,000 ft of the smaller sizes. The same type of machine is being used in Ontario this year to yard-wrap the 20-in. pipe for the connecting natural gas pipe line between the main import line and the Toronto city distribution system, a length of about 20 miles, to be wholly owned by Consumers Gas Company.

Ditching Problems

Practice in ditching is not uniform as to the relative merits of keeping ahead of or behind the pipe gang. In the well compacted soil of western Saskatchewan and central and eastern Alberta, ditch can safely be made several miles ahead in dry weather, as no caving is likely to occur. In other regions, particularly in Manitoba and eastern Saskatchewan, and in the foothills muskeg, it is essential to keep as little open ditch as possible, and some contractors adopt the method of pushing pipe as fast as the pipe gang and firing line can travel, even up to 15 or 20 miles ahead of the ditch, as open ditch even overnight in these areas can be dangerous and costly, owing to the crumbling characteristics of the ground, as well as the constant risk of bad water intrusion.

Ditch Water

Water in the ditch in the past two seasons in the eastern prairies, and in the Rocky Mountains in both the 1952 and 1953 seasons on the Trans Mountain line, has required pumping out in many places in order to keep the pipe from floating. In especially bad muskegs, a common practice in the foothills was to attach concrete river weights and float the pipe just below the surface. On the prairies, "spot" backfilling has been resorted to behind the dope gang, to sink the pipe to the bottom of the ditch with a few cubic yards of fill at intervals of 20 to 30 yards, final backfill being done the next day.

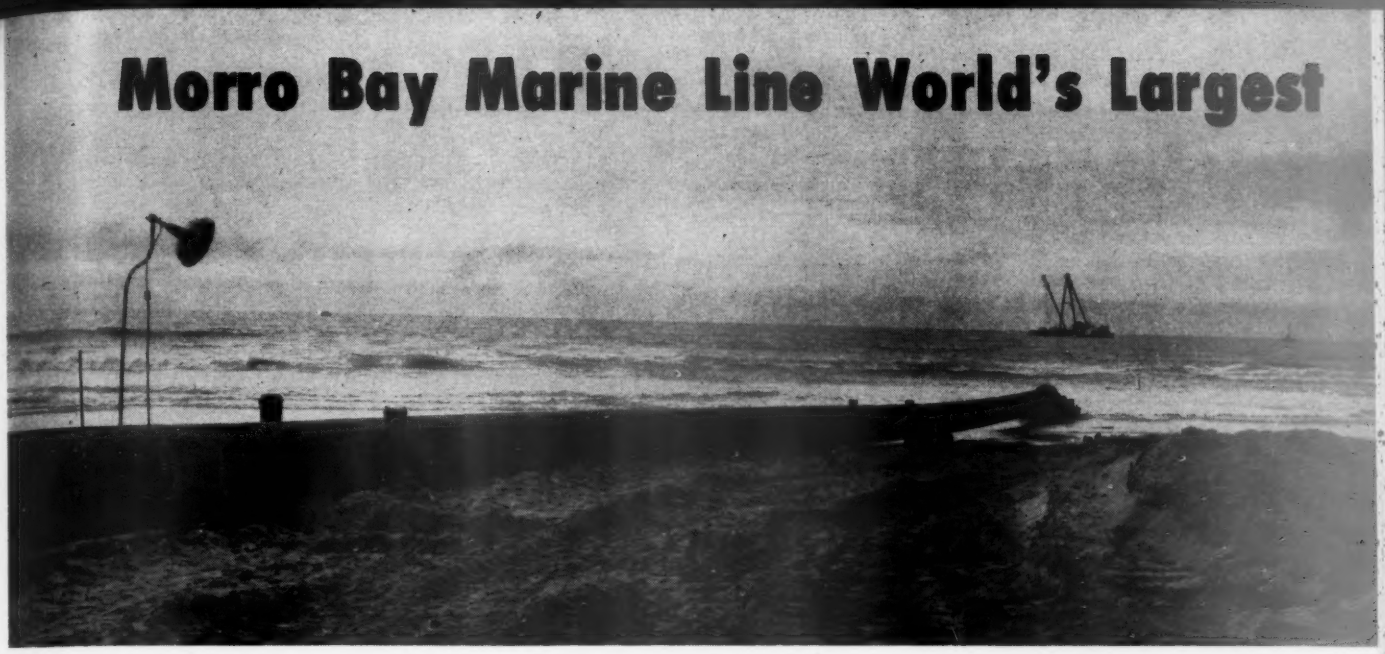
River Crossings

A unique feature of Canadian pipelining is the handling of river crossings. Due to the short summer season, and the usually heavy flow of water during this period, is has been found easier to put in water crossings through the ice in mid-winter when the flow is at its lowest point. This was done successfully in the case of most of the major river crossings on the Trans Mountain line in the winter-weather areas beyond the lower Fraser River valley. Ditching was done with backhoes, operating from platforms on the frozen river surface and pipe was lowered through the ice.

The same method of crossing the North Saskatchewan River with the Interprovinical line from Redwater to Edmonton was used effectively, but a later attempt to cross the South Saskatchewan at Outlook, Saskatchewan, at the end of March came to grief because the ice was too soft from the early spring thaw and the contractor lost several tractors through the surface, and was then compelled to pull the entire mile of welded and wrapped pipe back to shore and put in the crossing in the latter part of the summer. Exigencies of construction time have dictated whether it was feasible to wait for winter river crossings, and the third crossing of the river at Outlook, this summer, is being done by conventional methods during the ice-free period.

* * *

Morro Bay Marine Line World's Largest



EXCLUSIVE

P 615.372

Sideboom tractors replace railroad in launching 4460-ft, 24-in. California offshore fuel oil line weighing 300 lb per lineal ft

JAMES WALLACE

AT 1:00 a.m. on the morning of August 25, 1954, the operation of pulling to sea the largest marine fuel line ever constructed, and launched in this fashion, was begun. The line was constructed for the Pacific Gas and Electric Company to supply fuel to its 312,500 kw steam generator plant now under construction at Morro Bay, California.

The line, which extends 4460 ft into the bay and weighs approximately 300 lb per ft, provides a convenient location from which fuel can be transmitted from ocean-going tankers to the steam plant without the costly construction and maintenance of a pier, with its inconvenience to navigation.

Basically, the problem was to pull through the surf, from a barge anchored in the bay, long lengths of pipe, previously assembled on the shore, which when joined one after the other formed a continuous pipe line of the required length.

Tractors Replace Railroad

Heretofore, the commonly used method has been to construct a railroad system with cars to carry the lengths of pipe down the beach, the cars then dropping from beneath the pipe into a pit located above the high water mark. There is control of the pipe only to the high water mark, leaving the pipe that is exposed at low tide lying with its full weight on the beach. Besides requiring the construction of a sturdy railroad system, this method also requires that the railroad be dismantled and removed upon completion of the project.

At Morro Bay, a new but completely satisfactory method was tried employing the use of sideboom tractors. With this system, it was possible to carry the land lengths of pipe directly to the waters' edge, regardless of tides.

The author (center, left picture) checks field joint coating with holiday detector during push job.
Welding stringer bead (center) between main lengths during launching. Complete joining operation, including welding and field joints, required approximately three hours each for the four tie-ins.
Wooden slats (right) were placed over the field joints to protect the coatings, in place of concrete which would not have had time to cure properly.

XUM

REPAIR LEAKS
QUICKLY—PERMANENTLY

SKINNER-SEAL PIPE JOINT CLAMPS stop leaks at joints. Put on under pressure—without interruption of service. Quick, simple, lasting repair. Sizes 1/2" to 24" incl. in stock.

SKINNER-SEAL COLLAR LEAK CLAMP—designed to stop every type of collar leak in oil and gas lines. Sizes: 2" to 13" inclusive.

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SOUTH BEND 21, INDIANA, U. S. A.

MOLE
Pipeline
Cleaner

for BETTER cleaning of

CRUDE LINES

PRODUCT LINES

NATURAL GAS LINES

FOR DETAILS WRITE

Pipeline Cleaners Co.
Fort Madison, Iowa

Twelve sideboom tractors and one dozer tractor pushing move up third section of line for alignment and welding shortly after sunrise.

Tide Conditions Important

The date of the launching was chosen because of favorable tide conditions—a very low tide and a very high tide on the same day. The tide was important because, at the point of launching, it approached the pipes' centerline, not straight-on but at an angle of approximately 30 deg.

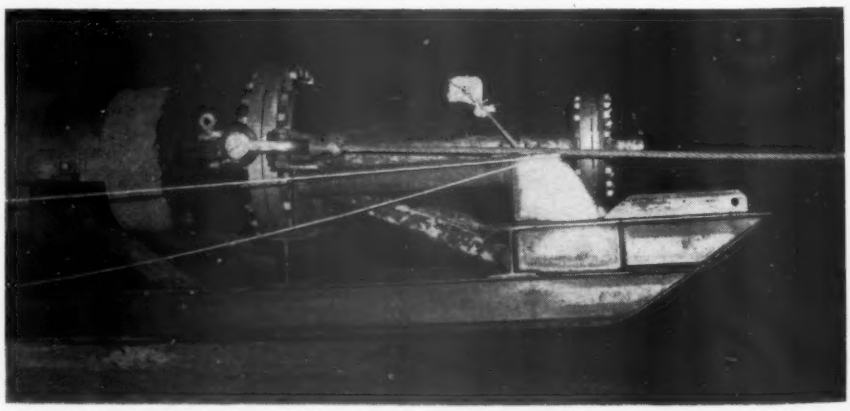
By beginning the first pull on a low tide, when wave action was at a minimum, the pipe had an opportunity to pioneer a path for itself through the surf. Once the pipe had formed a groove, it tended to act as a rudder in maintaining a true alignment. The last pull was scheduled and completed on the high tide, This was important because at that time most of the pipe was submerged, which provided bouyancy, and thereby reduced the final pull load on the barge.

Special Equipment Fabricated

Although the launching was on August 25, work was begun in June. On an operation of this nature, the planning is the most important part. Everything depends upon the one day of the launching because it is a single chance operation. Once the pull is begun it has to continue because, for should the pipe remain dead in the water for any length of time it will become packed with sand to such an extent it will be almost impossible to move again. Of course, adequate measures were considered should an emergency arise, but every precaution was taken.

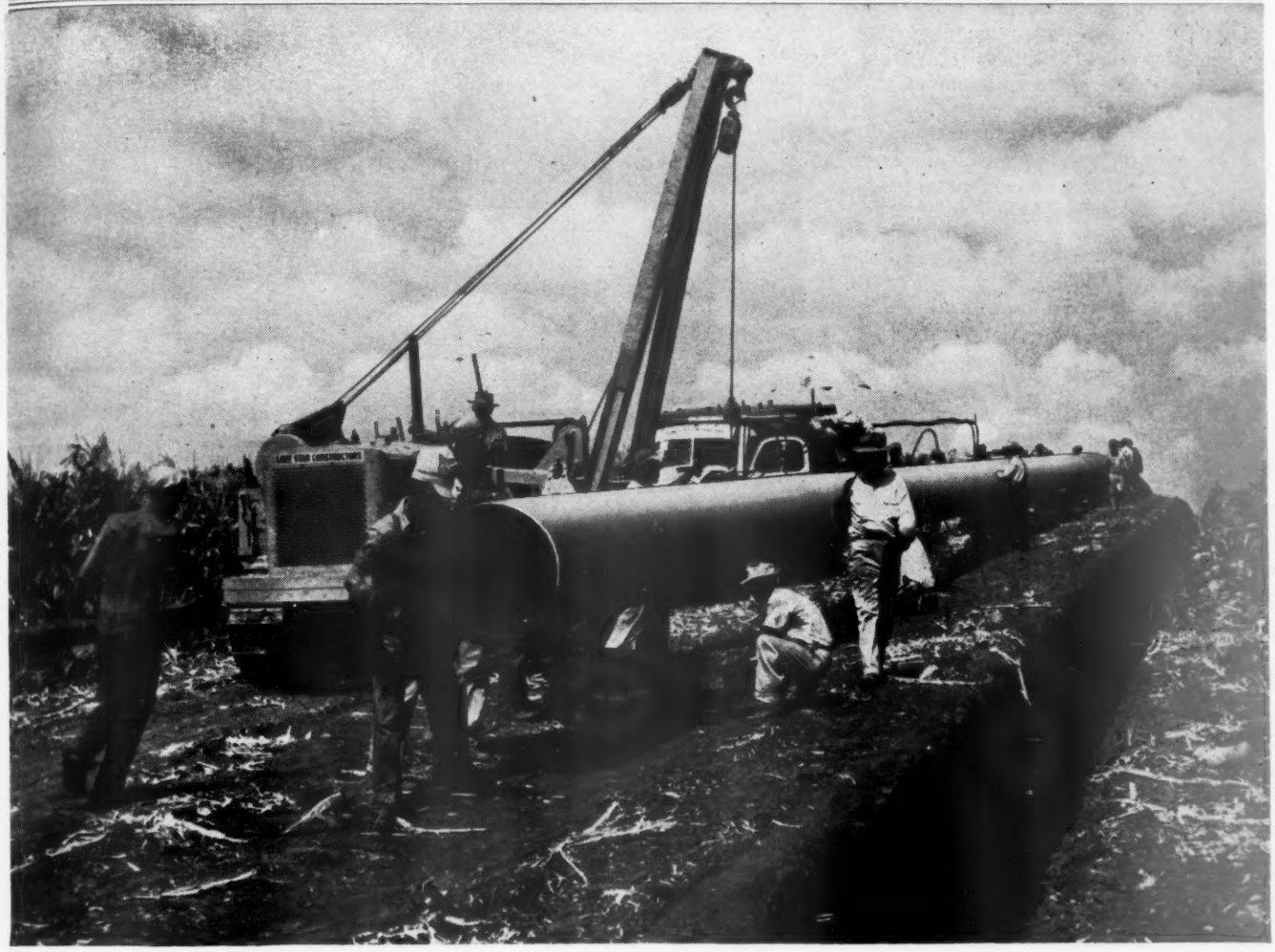
The Author

James Wallace was the project engineer for the Hood Construction Company on the Morro Bay job. He has had varied experiences in the construction business since his graduation from the University of Southern California in 1948. He was job engineer for the Fluor Corporation in the construction of a refinery for Columbian Petroleum Oil Company in Columbia, South America, and functioned as a field engineer in the construction of the Damskammer steam power plant in New York, constructed by Burns and Roe, Inc. Wallace has been with Hood Construction Company since January, 1953.



Special equipment built for the job included this sled to fit the seaward nose of the pipe, support it, and provide a smooth bed on the ocean floor to receive the pipe. Pulling clamps were welded directly to the pipe so force would not be exerted against flanges. The 24 by 12-in. reducer can be replaced with larger facility when increased plant capacity requires it.

PIPE LINE PROGRESS



Northern Natural achieves billion cu. ft. daily line capacity... builds with A. O. SMITH LINE PIPE

Northern Natural Gas Company this year completes its expanded two-year construction program, with total daily pipe line capacity up to 1,100,000,000 cu. ft. 460 miles of new main line loops were laid in the two-year program, with twelve sections of loop line being laid each year. New line facilities bring natural gas to 71 additional communities in Iowa, Nebraska, Minnesota and South Dakota . . . so that the company now serves a total of 307 communities in the Northern Plains.

A. O. Smith's participation in the job consisted of 178 miles of 30-inch pipe and 60 miles of 20-inch pipe.

Highly regarded in the industry because A. O. Smith welded steel pipe is consistently accurate in size, roundness and end-to-end matchup. A. O. Smith has supplied all or a part of the line pipe for most major pipe lines in the country.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

The A.O. Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

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XUM

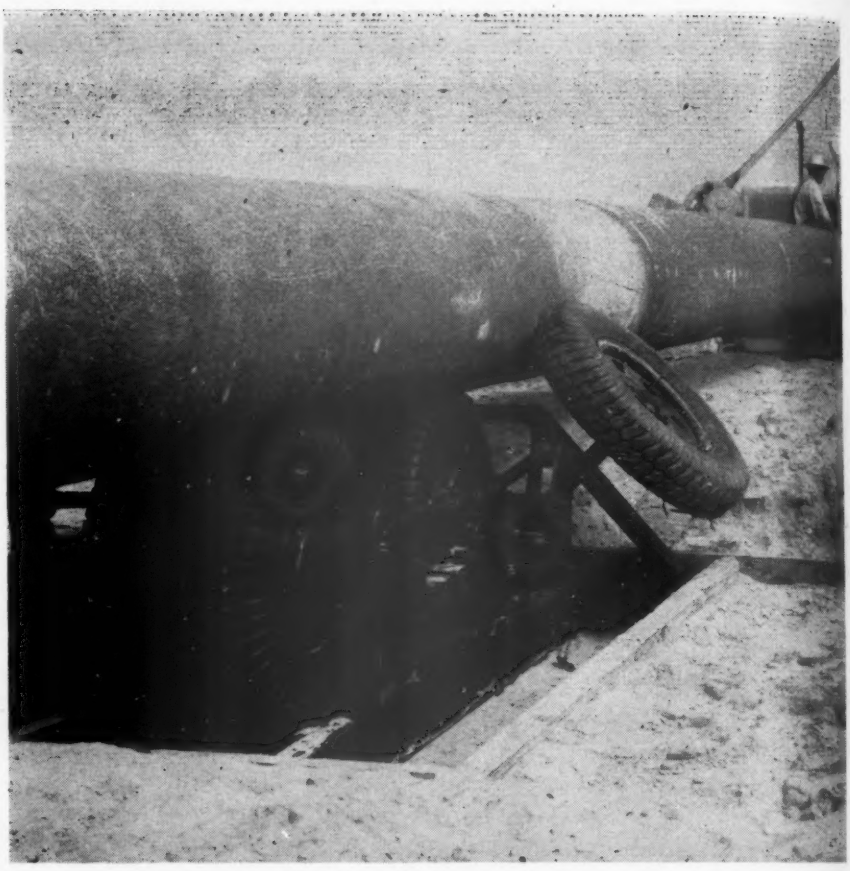
Special equipment had to be designed and fabricated for the project. A sled was made to fit the seaward nose of the pipe line so that it would slide along the ocean floor in the smooth bed made by the sled's flat bottom. A guide was manufactured from an inverted truck frame and tires. This provided a true alignment on shore before the pipe entered the water and prevented damaging the coating.

An area on the beach was cleared of dunes and debris and an access road constructed. Timber skids were positioned on which the joints of pipe would be aligned for welding.

Ocean Floor Examined

While this activity was taking place on shore, action was also taking place in the water. A diver was engaged to walk the proposed pipe centerline to determine the actual condition of the ocean floor. He reported a smooth, firm bottom ideal for this type of operation. Had any obstruction occurred, the way would have had to been blasted clear.

In July the pipe arrived. Individual joints were random 40-ft lengths with a ½-in. wall thickness. They were covered with a ¾-in. Somastic coating and a 1¼-in. concrete coating. The concrete was applied to protect the Somastic during the pull and to provide for sufficient negative buoyancy.



Guide fabricated from inverted truck frame and wheels was another special piece of equipment. It provides true alignment for pipe as it enters water and prevents damage to pipe coating.

PIPELINE KETTLES
STATIONARY CLEANING & PRIMING MACHINES
YARD PIPE RECONDITIONING EQUIPMENT
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MODEL 211-10 P2
PIPELINE COATING KETTLE
For transporting on highway.
For tough pipeline terrain.
10 Barrel capacity, complete with hydraulically operated agitator and low pressure burner, self-starting air cooled gasoline power unit. Mounted on tandem rocker beam assembly. Equipped with pneumatic tires and detachable (tire) tracks.
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SPECIALIZED EQUIPMENT FOR THE PIPELINE INDUSTRY

For pipeliners—

quality is the payoff

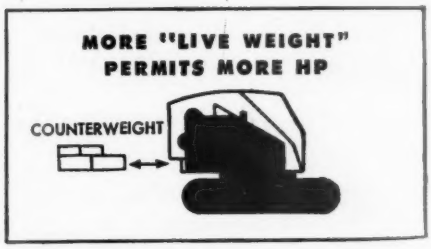
This ½-yd LS-51 trench hoe, owned by Somerville Construction Co., Ada, Mich., is working on a major oil company's pipeline.

This LS-51 hoe, with *Speed-o-Matic* controls, does more work and costs less to maintain

THE Link-Belt Speeder ½-yd LS-51 is a quality-built machine from its track shoes on up. It delivers more *usable* hp, 55 net hp at full load speed . . . and it has the "live weight" or stamina to handle it (see box). And, there's Speed-o-Matic controls, the power hydraulic system that's proved itself the fastest, easiest to operate, most accurate and trouble-free control system ever developed for shovel-cranes.

When you buy an LS-51—as is the case with all Link-Belt Speeders—you get a machine built to handle anything in its work range. You won't have to keep "beefing" it up. You won't be getting "nickel-and-dimed" to death for maintenance. A standard LS-51 incorporates many work-speeding features found only as optional equipment on other rigs.

So get the facts now. Contact your Link-Belt Speeder distributor or write for catalog 2428.



COMPARE ½-yd shovel-cranes with and without counterweights. This test spotlights the size, weight and heft built into the working parts and structure. You'll find the LS-51 has more "live weight."

LINK-BELT SPEEDER CORPORATION, Cedar Rapids, Iowa 13.476

BUILDERS OF A COMPLETE LINE OF CRAWLER, TRUCK AND WHEEL-MOUNTED SHOVEL-CRANES

LINK-BELT SPEEDER

Final Preparations

Pipe was unloaded from trucks and placed on skids. Joints were aligned and welded into 5 lengths of 835 ft each and one of 285 ft. Welds were X-rayed and a field jointers applied to match the existing plant applied coating. These lengths were then allowed to remain on the skids for 28 days to permit the curing of concrete at the field joints.

On the day preceding the launching the short, 285-ft lead length, with sled attached, was moved in front of the first 835-ft length. Both were positioned on centerline and joint welded. This weld was not X-rayed but was performed under continuous inspection. A Somastic field joint was applied and, for protection, was bound with wooden slats instead of the concrete coating, which would not have had time to cure.

The pulling barge was anchored at a point beyond the final end of pipe. A cable was brought ashore and firmly attached to the pipe line. The barge used had a 100-ton mooring capacity and could exert a 143,000 lb line pull at 22 ft per minute. Two way radio communication was established between barge and the shore. During the pull, walkie-talkie equipment was kept in operation so that in the event of failure of the two-way radio communication, the walkie-talkie could take over.

The Big Pull

All was now ready for the launching. The time for beginning was 1:00 a.m. and the beach was flooded with light. The 12 sideboom tractors lined up on one length of pipe made a truly impressive picture. One bulldozer was stationed at the rear to provide a push with which to assist the barge. As the pipe moved slowly down the beach, the sidebooms were disconnected, one by one, at the water's edge.

The pull continued until the rear of the first length lined up with the front of the next length, which was then rolled into position, the joint completed and the pull continued. Completion of each joint required approximately 3 hours. This procedure was followed until the pipe line was completed. The entire operation went off smoothly and was finished on schedule in approximately 16 hours elapsed time.

Final Completion

On the low tide of the following day, the shore end of the pipe line was buried and construction begun to connect the pipe with the storage tanks. Navy type anchors weighing 10 tons were placed at predetermined positions about the sea end of the line. All points were located by means of triangulation from a base line established on the shore. The anchors were placed in position using a derrick barge with a 100-ft boom capable of lifting 50 tons. Buoys connected to these anchors will be used by the tankers while discharging fuel.

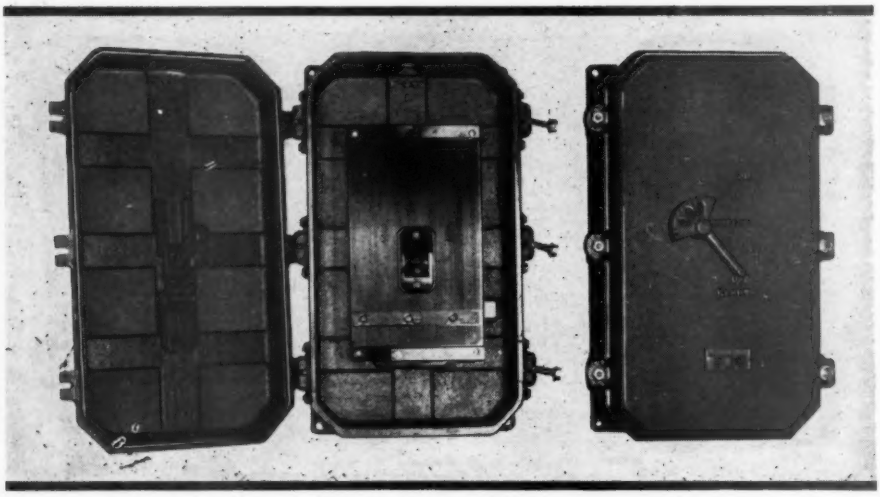
A 200-ft by 12-in. diameter flexible hose will be attached to the sea end of the pipe line. The outer end of the hose will then be attached to a buoy for easy pick-up by the tankers for discharging fuel.

While the 24-in. line is somewhat in excess of the initial capacity requirements of the steam plant, Pacific Gas and Electric Company is looking ahead to future expansion requirements to supply electricity to the fast growing population of the central California area.

Hood Construction Company of Lynwood, California, engineered and constructed the line for the Pacific Gas and Electric Company. Bechtel Corporation performed the construction work on the steam plant and their field office cooperated in the construction of the line. Healy-Tibbitts Construction Company subcontracted the marine work. * * *

Specify NELSON

WATER-TIGHT & DUST-TIGHT AIR CIRCUIT BREAKERS



Inside and outside views: Nelson 225-ampere frame, 3-pole, 250-volt breaker with 125-ampere trip rating.

Designed to provide automatic fuseless protection and control for power and lighting circuits, Nelson water-tight and dust-tight (NEMA IV & V) air circuit breakers:

1. Utilize thermal-type breakers, assuring dependable circuit protection.
2. Enclosures of high tensile cast iron are produced in our own foundry.
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Write for descriptive bulletin.

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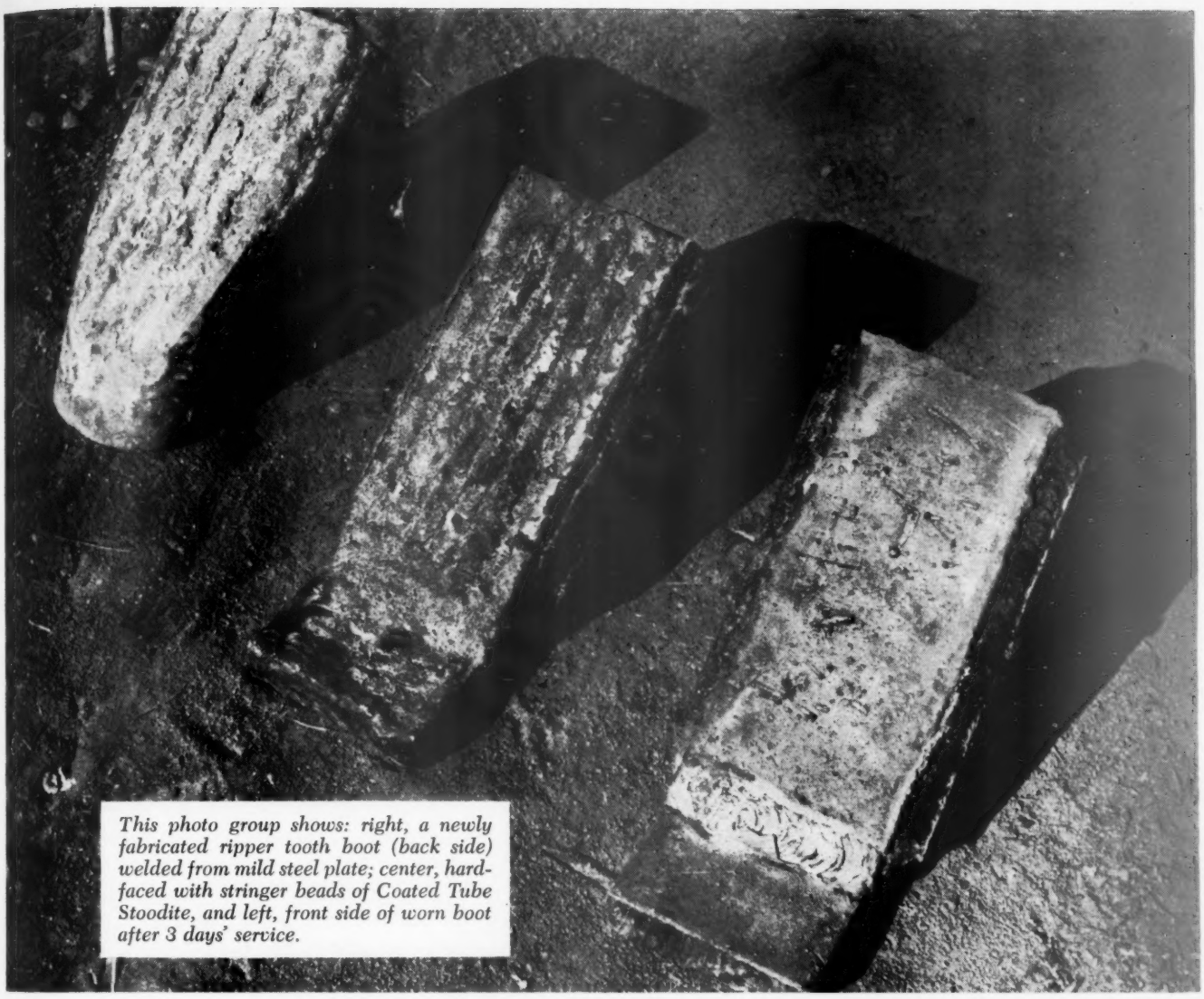


This photo group shows: right, a newly fabricated ripper tooth boot (back side) welded from mild steel plate; center, hard-faced with stringer beads of Coated Tube Stoodite, and left, front side of worn boot after 3 days' service.

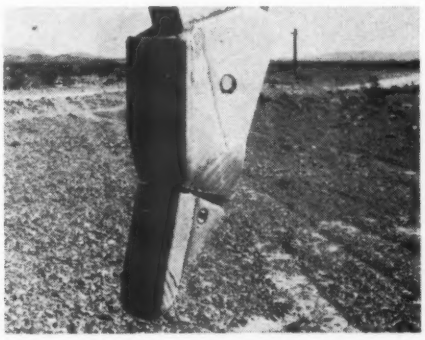
HARD-FACED RIPPER TOOTH

Lasts 1200% Longer on Desert Duty!

Near Ludlow, California, PG&E is spanning the vast Mojave Desert with a gas pipeline. To ease the trenching job a gigantic ripper is towed by a D7 tractor ahead of the ditcher. Its purpose is to break up the hard-packed earth and locate the frequent sub-surface lava flows. This lava is so hard and tightly bonded that explosives must be used to break up the formation.

Depth at which ripper operates is evident by length of standard.

The ripper on this job is designed for easy maintenance; boot type point and adapter are replaceable. The points are fabricated from mild steel plate in the division headquarters maintenance shop of the pipeline company handling the job, Engineers Limited Pipeline Co., Bakersfield, California. All four sides are hard-faced with Coated Tube Stoodite before being placed in service.



Close-up shows point attached to tooth adapter. Entire tooth is hard-faced with Coated Tube Stoodite.

Working deep in the highly abrasive earth, unprotected boots last only 2 hours. When hard-faced with Coated Tube Stoodite this short life is extended to three full days—an increase of 1200%.

Coated Tube Stoodite is a recent Stoody development for manual application, combining high wear resistance, good impact strength, fast deposition and low cost. Ask your Stoody dealer for details (consult the yellow pages of your phone book) or write direct.

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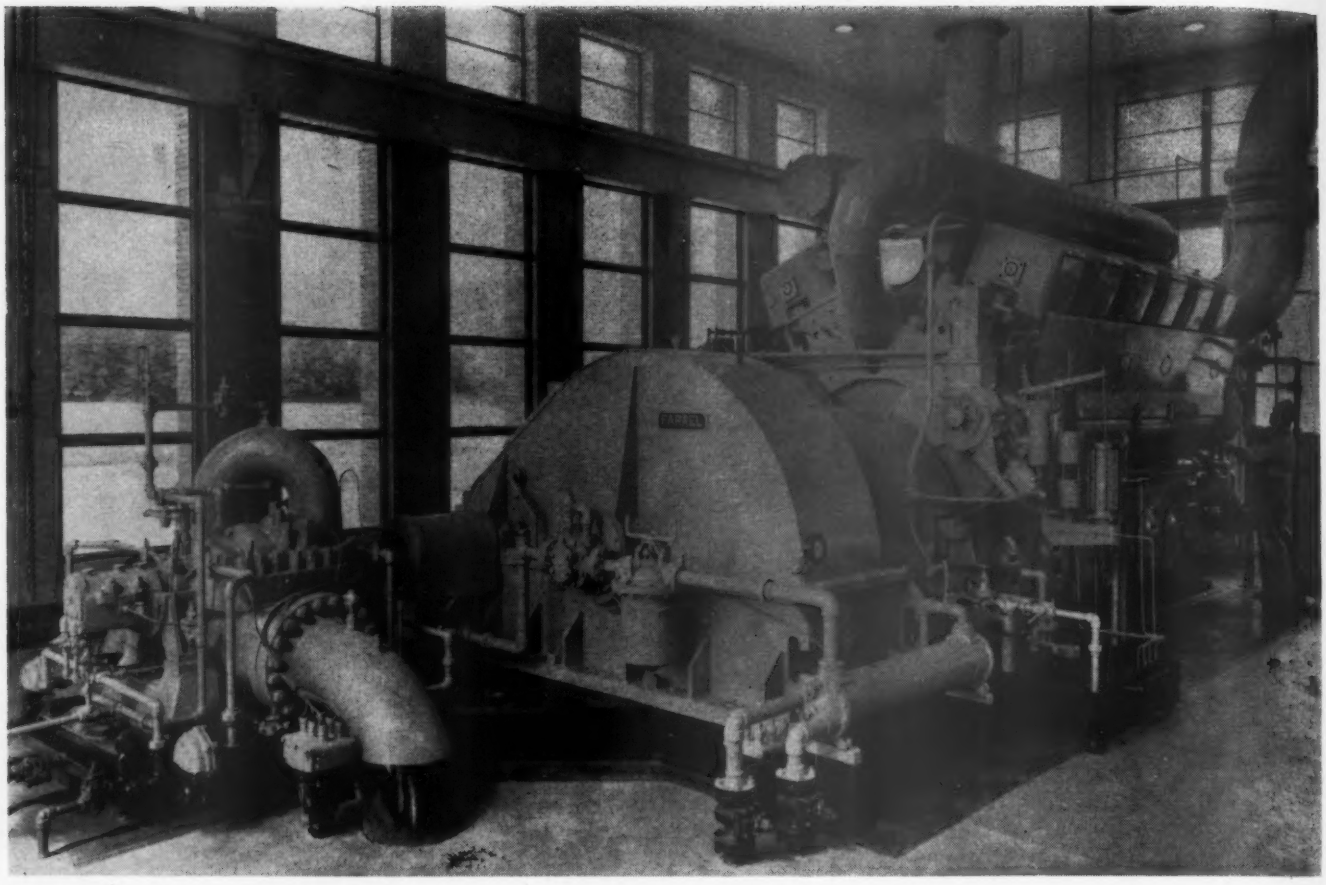


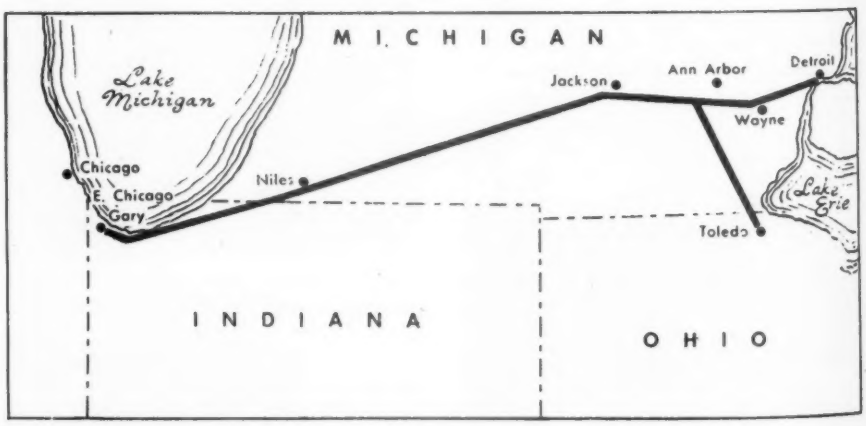
The 2650-hp V-type diesel at Vicksburg station drives a two-stage 3220 gpm centrifugal pump through a 10,189:1 speed increaser.

New common carrier products line serving Great Lakes area combines many modern features in its design

Wolverine System Has Unique Equipment, Operation

MANY modern design and engineering features are combined in the new 295-mile Wolverine Pipe Line 16-in. products carrier, a $15,000,000 project that links refineries in East Chicago to two major market areas, Detroit, Michigan and Toledo, Ohio.

In addition to providing new transportation capacity to the rapidly growing oil markets in Detroit and Toledo, the new line also makes possible year-around movement of products to these cities. Previously, those areas were dependent primarily on Great Lakes shipping and had to rely on storage build-



Map shows route of the 295-mile, 16-in. products pipe line system operated by Wolverine Pipe Line Company, joint venture of Shell, Cities Service, and Texas Company.

EXCLUSIVE

up, a tremendous annual headache, to take care of demand during the long winter freeze on the lakes.

The line begins at Hammond, Indiana, and runs eastward to a point near Ann Arbor, Michigan, where it branches into two segments, one to Detroit and the other to Toledo. Three companies participate in the ownership, and joint venture of Shell Oil Company, Cities Service Oil Company, and The Texas Company. Design, construction, and operation of the line is in charge of Shell.

Products are received at Hammond through private feeder lines from Cities Service's refinery, and from Shell and Texaco terminals in nearby East Chicago. In addition to the terminals at Detroit and Toledo, shippers also have take-off terminals at Niles and Jackson, Michigan.

Initial capacity of the line is 95,000 bbl daily, and products handled include diesel fuel, No. 3 fuel oil, premium and house brand gasolines, kerosine, and prime white. Capacity of the line can be boosted to 170,000 bbl daily with construction of intermediate pump stations.

Two stations provide the initial pumping capacity. They are located at Hammond and Vicksburg, Michigan. The Kennedy Avenue station at Hammond is the key operating point for the entire system, with two 1250-hp electric motors driving 2-stage centrifugal pumps providing initial pressure for the line.

Control of operations is centralized in a separate building. Lights on a large control console indicate the position of all tanks, valves, meters, and pumps on the line and show which are operating. The station operator has finger tip control over all equipment and by pushing a single button he starts product flowing from any one of the shipper's tanks. In a similar way, the operator starts and stops one or both of the station pumps.

The Kennedy operator can, if necessary, extend his control more than 100 miles to the Vicksburg station via teleprinter hookup. He can dial code numbers to start or stop the pump at Vicksburg and also, by dialing other numbers, can obtain an automatic report of operating conditions at that distant station.

The Vicksburg station is markedly different from Kennedy. Power comes from a 12-cylinder, 2650-hp V-type diesel engine, the largest of its type ever installed on a pipe line. The diesel drives a 2-stage centrifugal pump rated 3220 gpm at 2152 ft head through a 10.189:1 (500 to 5094 rpm) high speed herringbone gear speed increaser. At a speed of better than 5000 rpm, the one pump develops as much pressure as the 2 identical pumps at the Kennedy station.

The new engine, the first of this V-type to go into operation, has 12 cylinders of 13-in. bore and 16½-in. stroke. It is of the 4-cycle type and develops its rated brake horsepower at 500 rpm. Designed for more compact and efficient generation of power, engine features high pressure turbocharging, intercooling, and variable compression ratio. It is presently operated up to 2000-hp without intercooling. With intercooling, its rating is increased to 2650 bhp, equivalent to 160 bmep. Later, it is planned to install a 3 to 1 pressure ratio turbocharger and increase the rating to 3200 bhp or 190 bmep.

In contrast to Kennedy station, the Vicksburg pumping and control facilities are housed in a single building of modern brick construction. The station is divided primarily into three operating sections; the engine-pump room, auxiliary room, and control room. All three rooms are attractively tiled and painted assuring clean, pleasant operating conditions. The station, in addition, has a lavatory and shower and a tool and repair room.

Safety was an important consideration in the layout and design of the Wolverine system and the automatic

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Protecto Wrap Cold Coating provides hot applied enamel quality of material and workmanship on oil and gas pipelines. It is particularly recommended for reconditioning, and for field joints and repairs to coating.

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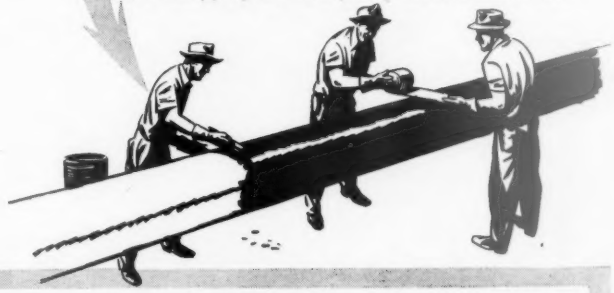
1. Protecto Wrap Cold Coating Primer consists of a heavy bodied bituminous coating that is applied by conventional brushing. Care should be taken to thoroughly fill all pits on reconditioned pipe with primer.
2. Protecto Wrap Cold Coating consists of a woven glass textile cloth saturated with asphalt or coal tar pipeline enamel. This coating is applied by spiral wrapping over the primer while it is still wet.



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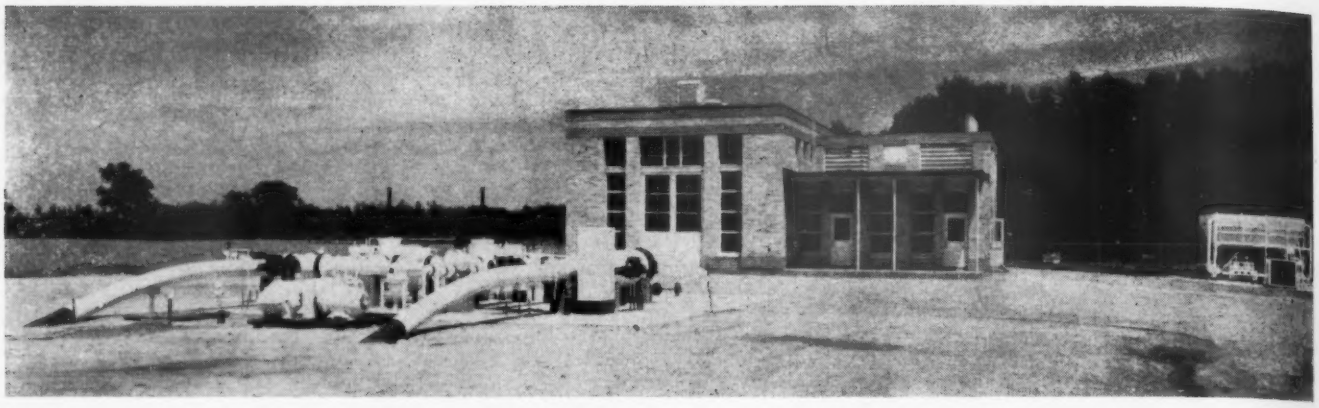


Good housekeeping and modern design are two of the many fine features of the Wolverine Pipe Line System. The attractive construction of the Vicksburg station is characteristic of its other facilities.

controls at the Vicksburg station are typical of the care given this feature. Controls are established so that any departure from regular operating pressures, temperatures, etc., both in the line and on the pumping unit, i.e.—high or low lubricating oil pressure, high cooling water temperature, engine overspeed—will shut down the equipment and in certain instances, the entire station. Mercoid controls are installed where required with the central control box located in the auxiliary room. A loud alarm alerts the operator and an annunciator on the control panel indicates the cause of the trouble.

Maximum line operating pressure on the Wolverine system is established at 900 psig and over-all direction and scheduling of the movement of products originates hundreds of miles from the line. This scheduling and other routine Wolverine operations are carried on under contract by Shell's product pipe line department, which has its headquarters in Radio City, New York. Dispatchers there maintain round-the-clock supervision of the entire line with the aid of teleprinters, carefully planned pumping schedules, and an ingenious dispatching board.

Key unit in following the pumping schedules is the 17-ft dispatching board. This board serves as a crystal ball, gives up-to-the-minute picture of the line telling the dispatchers at a glance exactly how much of what product is where at any time. A diagrammatic representation of the line, this board has markers representing the various stations and delivery points and lights show those in operation. The products in the line are represented by lengths of paper tape, scaled so that an inch represents a certain number of barrels of product and colored to identify the various products. So accurate is this system that the dispatchers are able to tell within minutes when a particular product will reach a determined point. For example, they can tell the deliveryman at a terminal to begin taking off 5000 barrels of premium gasoline at 2:35 pm and he will find the batch arriving on the dot.

Remote control starting of the engine pumping units at Vicksburg is equally ingenious and requires only 90 seconds. This system for automatic starting and operation of pumping units is similar to that employed on Shell's North line from its Wood River refinery to East Chicago and is referred to as the Norris Plank system. This system utilizes the usual engine governor only to prevent overspeed with the primary control of the engine functioning through direct hydraulic cylinders which position the fuel racks in response to changes in station suction and discharge conditions.

On a push button or automatic start, following the motor actuated opening of the main pump valves and the establishment of pump seal oil and engine oil circulation, the start cylinder receives air through a solenoid valve, extending its piston to open the fuel rack wide at the same moment as starting air is admitted to the engine. When the engine fires and differential pressure across the main pump increases, the solenoid valve to the idle cylinder opens, admitting air to retract the fuel rack to idle position. After a delay through an electric timer, the air is released at a controlled rate by means of a time tank, allowing the engine to transition from idle to control speed over a period of approximately five minutes. This multiple sequence insures time to warm up a cold engine and the gradual application of load.

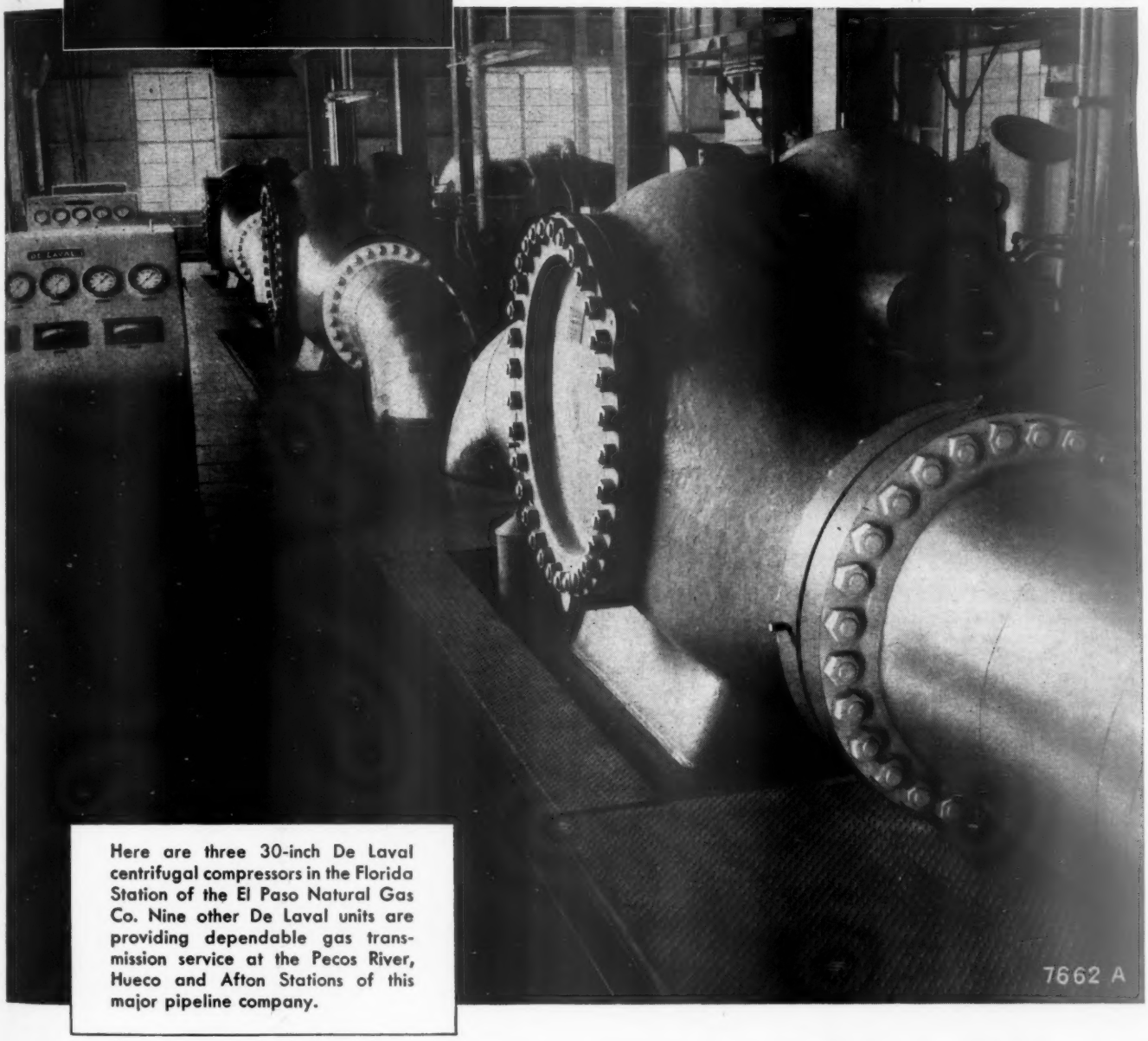
* * *

Control room of the Vicksburg station of the Wolverine Pipe Line with operators at the teleprinter and control panel. Note station diagram and lights on lower panel.

XUM

DE LAVAL
CENTRIFUGAL COMPRESSORS

on the job at El Paso Natural Gas



Here are three 30-inch De Laval centrifugal compressors in the Florida Station of the El Paso Natural Gas Co. Nine other De Laval units are providing dependable gas transmission service at the Pecos River, Hueco and Afton Stations of this major pipeline company.

De Laval centrifugal compressors offer many important engineering features. (1) They are designed to handle an increased ultimate flow, can be quickly converted to larger capacities by replacing the impeller, diaphragm and a few minor parts. (2) The high pressure shaft seal eliminates leakage, consumption of sealing oil is negligible. (3) There is only one moving part — the rotor — which has ample clearance. (4) Units are compact, require smaller foundations and smaller stations. (5) First costs and installation costs are low.

If you want detailed data on all the design advantages of De Laval centrifugal compressors, consult our engineers. They will be glad to give you the benefit of our wide experience on major pipelines.

DE LAVAL *Centrifugal Compressors*

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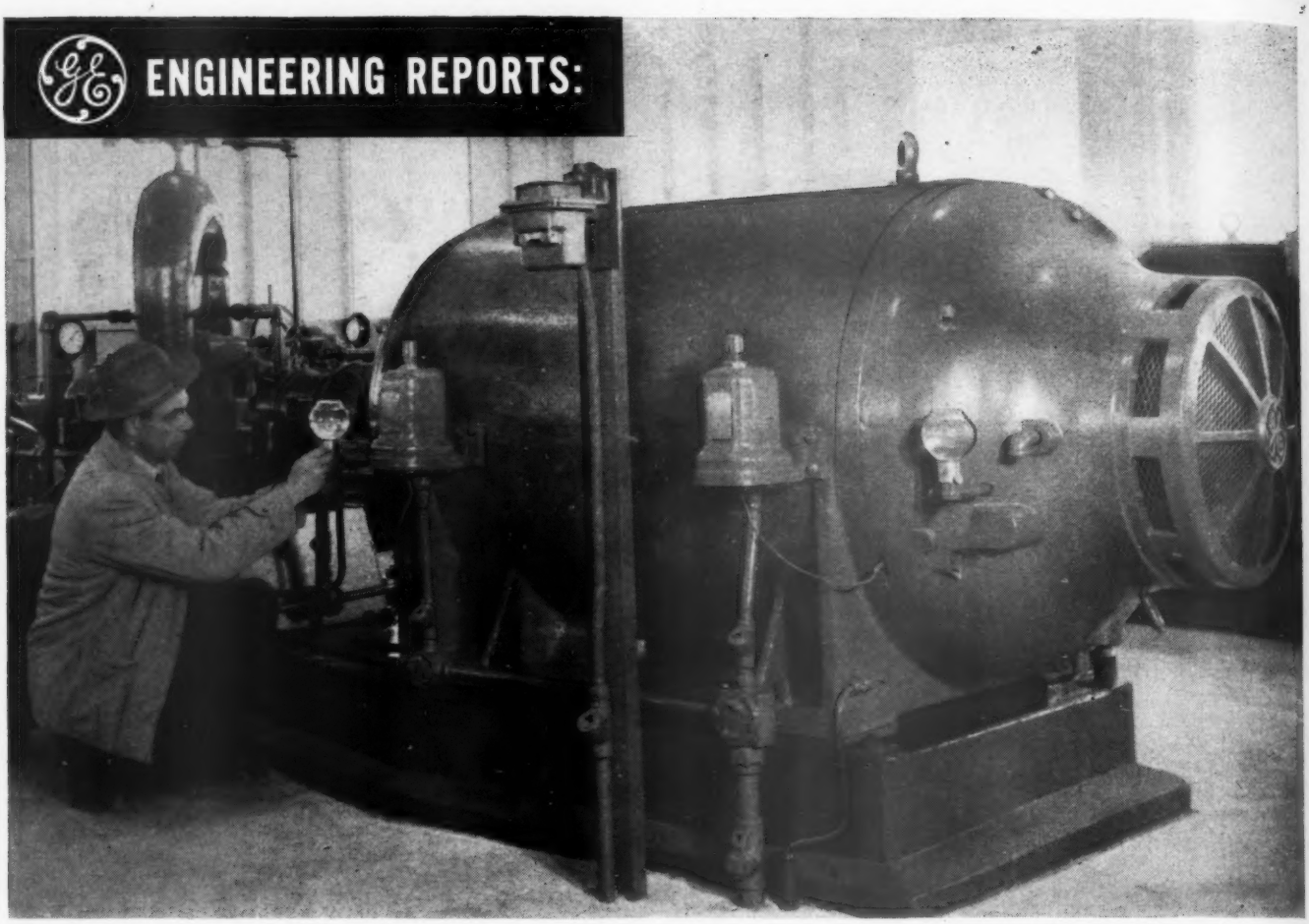
ENGINEERING REPORTS:



LOWER STATION CONSTRUCTION COSTS were possible because use of three G-E explosion-proof motors eliminate need for an intervening firewall. Bearing temperature relays mounted on motors' sides help protect them against overheated bearings. These motors are built to require a minimum of maintenance at the pumping stations.

G-E engineering services cut planning time,

RELIABLE STATION PROTECTION is provided by G-E metal-clad switchgear using magne-blast air current breaker with adequate interrupting capacity.

SPACE-SAVING G-E safety switches and combination starters in control room, control air compressor, sump pump, and deep well motors.

3-WAY EXTRA PROTECTION against physical damage, electrical breakdown, and operating wear is built into vertical Tri-Clad* motors.

*Reg. trade-mark of General Electric Co.

SIMPLIFIED STATION CONTROL is possible with this G-E operator's console. Its explosion-proof emergency-trip push button can shut off at once every power source in the control room.

INSTALLATION COSTS WERE REDUCED with G-E factory-assembled 2300-v indoor metal-clad switchgear. Unit controls and helps protect main pumping motors.

speed installation of new Buckeye stations

General Electric Application Engineers co-ordinate electrical system, Field Engineers expedite start-up of Lehighton, and Nicholson, Pa. stations

Maximum safety precautions, minimum maintenance, high functional dependability—these were specified as "musts" for the electric equipment in two new pumping stations of the Buckeye Pipe Line Co. That's why General Electric Application Engineers were called in early in the planning stages of Buckeye's Lehighton, and Nicholson, Pa. stations.

Working closely with Buckeye's engineers, and contractors and consultants, Pipe Line Engineering Co., these G-E engineers helped develop a co-ordinated electrical system that economically met all the specifications. And G-E Field Engineers, on hand for the installation, helped speed a smooth start-up.

Now with the line in operation from Linden, N. J. to Auburn, N. Y., Buckeye reports complete satisfaction with the performance of the electrical system, and the G-E engineering services used at these stations.

Whatever your pipeline electrification needs, G.E. can provide a broad line of motors, control, and power-system equipment—co-ordinated for maximum efficiency. And no matter where your pipelines run, G-E service facilities nearby can help you keep your equipment at peak performance levels. For more information, contact your local G-E Apparatus Sales representative, or send for 40-page bulletin GEA-5423 on electrified oil pipelines to General Electric Co., Section 661-46, Schenectady 5, N. Y.

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Oil - Gas - Gasoline - Water Pipe Lines
2707 FERNDALE HOUSTON 6, TEXAS

Strung out over this rolling country right-of-way in Mississippi are these 40-ft joints for the first 36-in. natural gas line to be built.

P 620.5

First 36-Inch Pipe Laid

Transcontinental Gas Pipe Line's loops in Mississippi, Alabama open new era in "big-inch" construction; construction methods, concepts of organization markedly different from ordinary procedures

DEAN HALE*

Clamshell cuts bell holes in ditch at intervals of 40 ft.

BIGGEST pipe ever laid for gas transmission service is the foremost feature of approximately 47 miles of 36-in. loop lines under construction for Transcontinental Gas Pipe Line Corporation in Mississippi and Alabama by Associated Pipe Line Contractors, Inc.

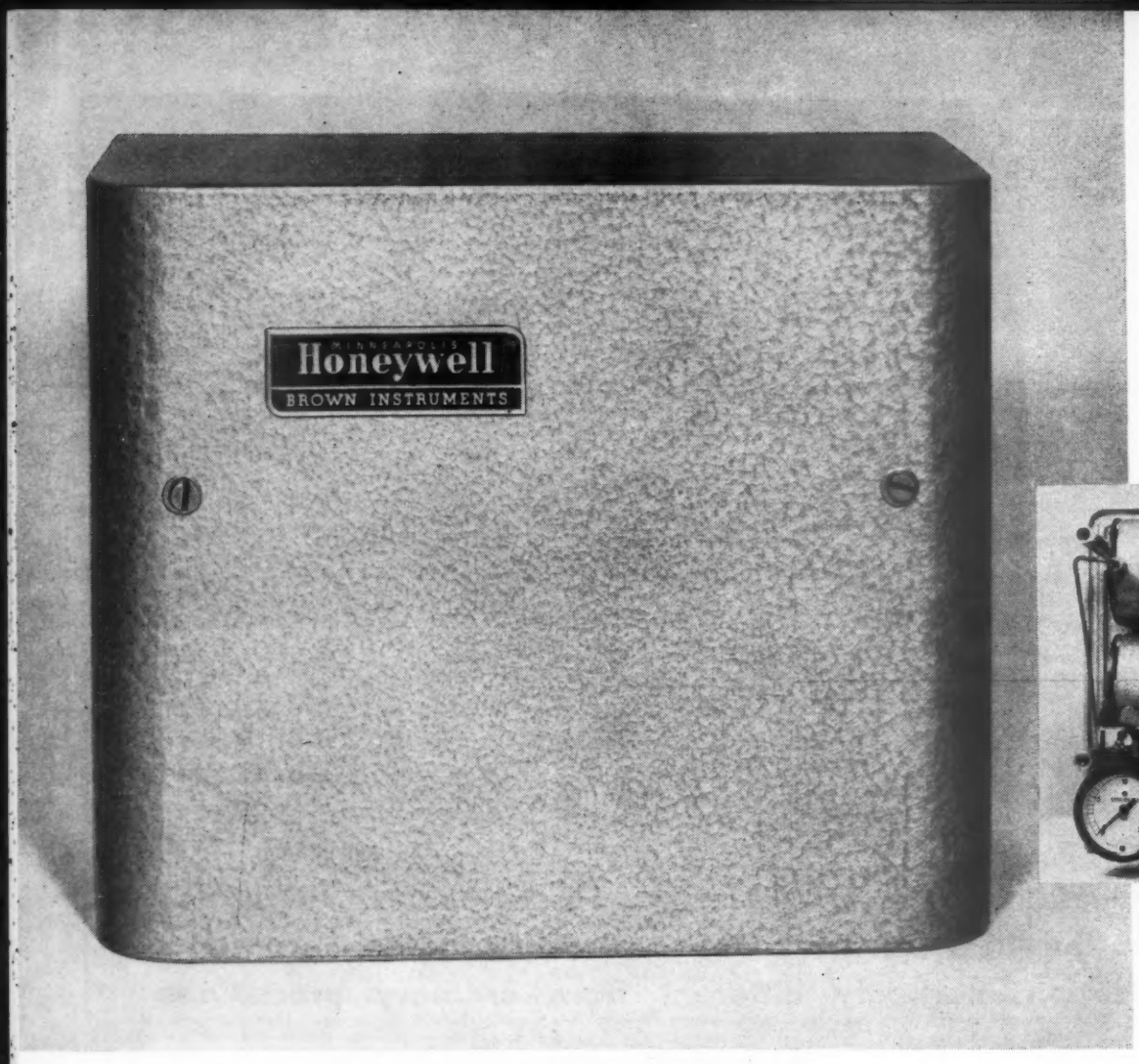
Pipe size for this "super-duper-big-inch" project isn't the whole story. Many unique ideas in construction methods are among the unusual features of this project involving really big diameter pipe.

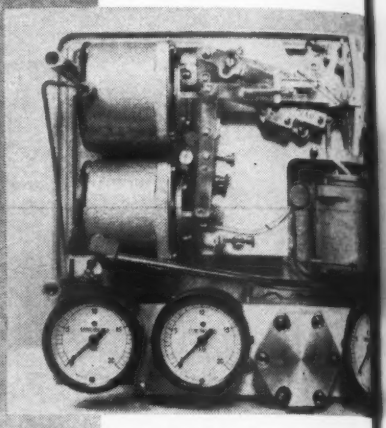
Most noticeable in the construction of the line is the actual fabrication of the line itself. All pipe work is done deep in the ditch, where bell holes have been cut to accommodate pipe gang welders, firing line welders, x-ray technicians, and the crews making field joints.

Use of bell holes is not new on pipe of about this size. On the Pacific Coast, PG&E's 34-in. "Super-Inch" was stove-piped in the ditch using the bell hole method. Working in the ditch is not new to contractors building big-inch river crossings, either, though in the latter case, ditch is usually cut very wide to allow ample movement of personnel.

*Editor, Oil-Gas-Products Pipelining.

EXCLUSIVE





Interior view of Ratio R shows simple, compact struction. Pressure gages i cate input signals and out pressure. Adjustments for trol action, zero setting ratio range are readily ac sible.

The Tel-O-Set Ratio Relay offers these unique features:

★ **LINEAR RATIO**

Output changes in straight-line relation with primary variable. Permits better control tuning . . . eliminates "compromise" settings.

★ **DIRECT OR REVERSE ACTION**

Readily set to provide either increasing or decreasing output . . . increasing or decreasing ratio.

★ **FLEXIBLE ADJUSTMENT**

Ratio range can be reduced to any desired value. Reduced span can be positioned at any desired portion of the maximum range. Factory setting is 50—150% ratio range.

★ **WIDE RANGE**

Ratio can vary from 0 to 200% for a full scale change in the primary variable.

★ **ADJUSTABLE LIMITS**

Readily set stops are provided to limit minimum and maximum output pressure.

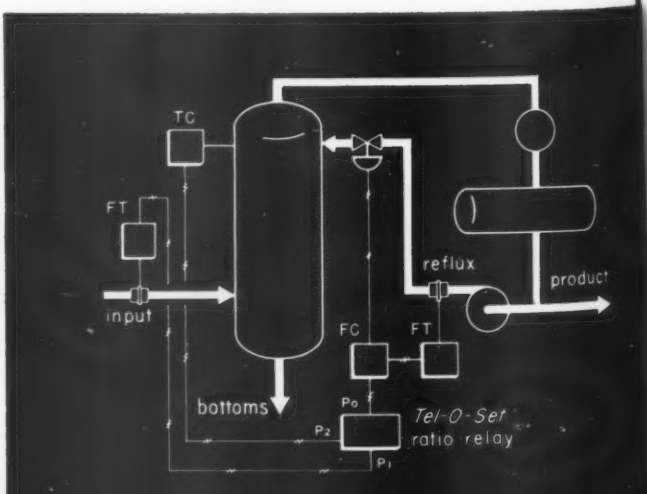
★ **ZERO SUPPRESSION**

Independent zero adjustments permit selection of the exact input-output relationship desired.

★ **INDICATING GAGES**

Separate indicators show output pressure and both input pressures.

On a distillation column, Tel-O-Set Ratio Relay receives air signal (P_2) from column temperature controller. This signal varies the ratio of the output pressure (P_0) to the signal received (P_1) from the input flow transmitter. Output pressure feeds into an *Indexet* remote setting index in the flow controller, to reset this instrument and thus throttle the valve in the reflux line. Ratio of reflux to input is thus varied in accordance with temperature of the top of the column.



XUM

New, versatile means for effecting cascade control

the Tel-O-Set Ratio Relay

HAVE a complex control loop? Here's a versatile way to simplify it . . . the new *Tel-O-Set* Ratio Relay. Another advanced idea in process control from Honeywell, this unique relay proves the ideal solution to complex cascade control problems.

The Ratio Relay provides automatic control with a single element influenced by three interrelated variables. For example, it is used on distillation columns (see diagram) to control the ratio of reflux to feed, as column temperature varies. In absorption towers, it regulates ratio of absorbent and feed stock to give constant concentration of product. And there are scores of other uses for this relay . . . in evaporators, controlled-atmosphere furnaces, reaction tanks, engine testing and other applications where several related variables must be interlocked for efficient operation.

The Ratio Relay receives pneumatic signals from remote transmitters, controllers or manual loading stations. It produces an output air signal for readjusting the set point of a secondary controller. It is the ideal companion for Honeywell Differential Converters, *Tel-O-Set* miniature instruments and Brown pneumatic controllers.

Your nearby Honeywell sales engineer will be glad to discuss applications to your specific process . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Bulletin 8410, "*Tel-O-Set* Ratio Relay."**

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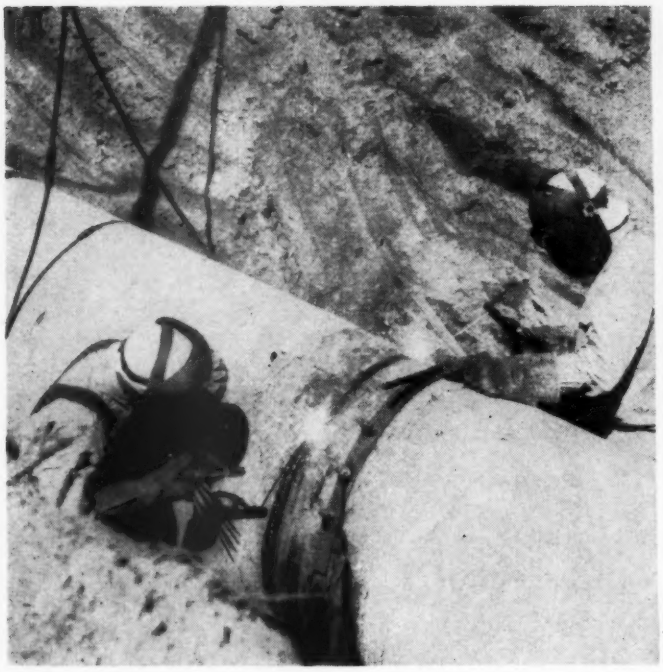
BROWN INSTRUMENTS

First in Controls



Making stringer bead in bell hole.

Pipe is lowered in one joint ahead of line-up.

Ditching With Backhoes

On the Transcontinental project, however, the "unusual" starts with the actual ditching operation. Instead of using a trencher, the contractor has put backhoes to work, cutting a 5½ to 6 ft wide ditch, 6 to 6½ ft deep, in order to allow for a minimum cover of 30-in. or more.

Ditching with backhoes can have its difficulties, as the contractor has found. Inclement weather can slow up the project miserably, resulting in the pipe gang being held up for "more ditch." Experience in Mississippi has been that 4 'hoes can cut from 2500 to 3000 ft of ditch daily as a minimum, and more under good working conditions.

Average Good Despite Newness

Practically everything about the 36-in. project is new to both the contractor's organization and to the company personnel. Despite careful planning, some "bugs" showed up in the early weeks of the job, but have been ironed out, and as the crews gain experience in their various phases, a daily average of 2500 to 3000 ft of pipe in the ditch is expected.

That average may seem low, compared to some averages of 5000 to 6000 ft per day on spreads constructing 30-in. or smaller diameter pipe lines. There is a big difference, though, between pipe gangs working on the right-of-way and over the ditch, and the bell hole method, where practically all operations are performed right in the ditch.

Pipe Yard Coated

Yard coating and wrapping of the pipe before it is hauled to the right-of-way and strung is a big aid to construction; it was also a practical move, as equipment to line travel the coat and wrap would be almost impractical if

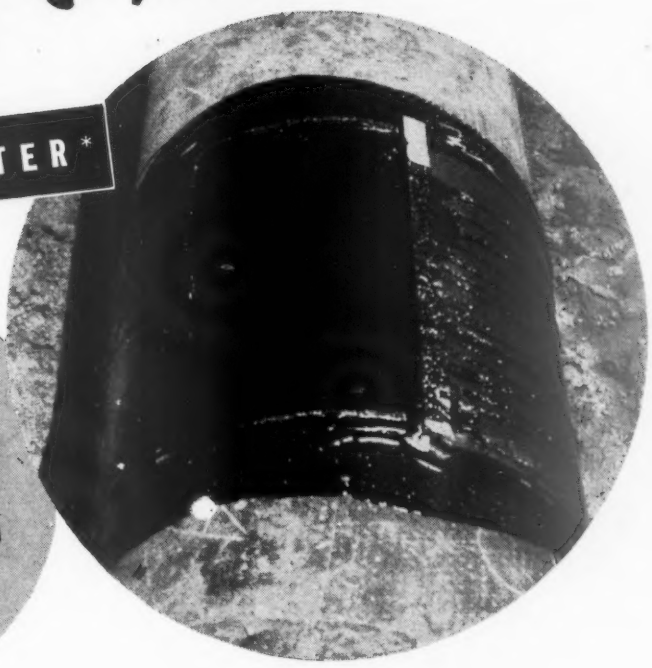
X-ray crew preparing to make top-half film.

Backhoes are used to cut ditch.

XUM

Coating Field Joints ... is NO Problem!

WITH THE FIELDJOINTER*



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The Fieldjointer can solve the problem of effectively coating field joints for you! The "granny-rag" method of joint coating is out. And there is complete elimination of soil distortion.

The Fieldjointer is manufactured under maximum pressure of very heavy, durable, moisture-proof, fibertex board and calendared to resist moisture under high pressures. The Fieldjointer is wide enough to overlap several inches of the previously coated and wrapped pipe; heavy felt inserts hold it ¼ inch away from the pipe. This space is filled with hot enamel, effectively coating the weld at the bottom, sides and top — all this with a minimum of labor and coating cost — and no loss of enamel.

Inexperienced labor can effectively apply these Fieldjointers. Two men can usually coat the field joints on small and medium sized pipe in a mile section in one day. Fieldjointers are available for pipe from 1" to 36" in diameter.

• *For complete details and prices, write S. D. Day Company.*

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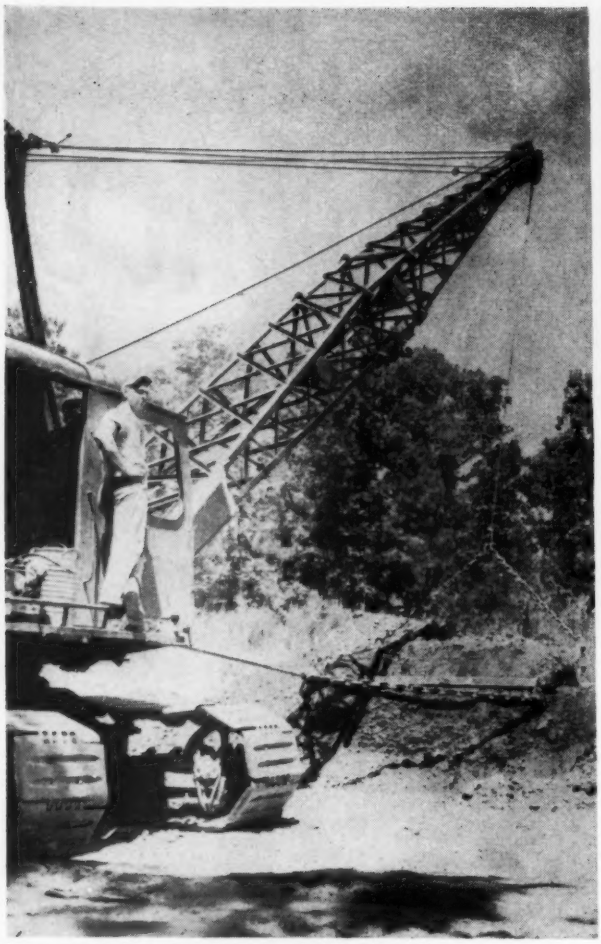


Firing line showing welders in bell holes, which are cut deep enough to give them ample room to work in.

Dragline with scraper plate is used for backfilling, moves equivalent of two to three dozer-equipped tractors.

not impossible. Investment that would be required in tractors, allied equipment, and labor force rules out such a method.

Small Compact Spread

Equipment and labor on the spread is kept to the minimum required to do a good job and at a speed requisite with conditions. Balanced against the daily average, the production from the small, compact spread (which works in an area about ½ to 1 mile between the first backhoe and the backfill) is very high. Spread layout runs like this: Backhoes cutting ditch, clamshell cutting bellholes, bending crew, pipe gang, firing line, field jointer crew, and backfill. Final clean-up may work anywhere from ¼ to 3 miles behind backfill, depending on what work is required and type of terrain.

Average amount of equipment used by Associated on its Mississippi spread includes 5 sideboom tractors, 4-5 backhoes, 3 dragline-clamshell units, 6 welders for pipe gang—3 mounted on tracks, 3 on truck, 8-10 welders for the firing line, tractor and dope kettle, bending machine, and trucks for personnel as required.

Size No Difficulty

Despite the size of the pipe, it is no trouble to handle. Good, smooth bends are made readily. Company engineering crews also find that the closely-knit work benefits them in laying out bends to make the pipe fit the ditch, and in making changes as the work progresses.

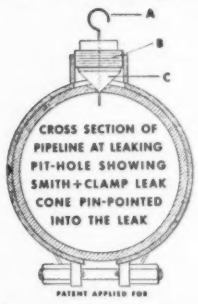
How fast the pipe gang is able to get the pipe joints in the ditch (all joints are 40-ft, weigh about 7000 lb with

THE WILKINSON LINE LOCATOR

will substitute *facts* for guesses and map errors

Wilkinson Products Co.
Originators of small, light all-purpose locators
3987 Chevy Chase Drive
Pasadena 3, Calif.

Smith+Clamp Permits Plugging and Welding Pit-Hole Leaks in a Pipeline While Pumping Through It.


A
B
C
CROSS SECTION OF PIPELINE AT LEAKING PIT-HOLE SHOWING SMITH+CLAMP LEAK CONE PIN-POINTED INTO THE LEAK
PATENT APPLIED FOR

Smith+Clamp shuts off more easily, quickly and safely than ordinary clamps. Use on high and low pressure gas, gasoline, crude oil, water, steam, air, chemical process and other pipelines. Sizes 1″ to 30″. Combine with WELDPLATE when pipe reinforcement is specified.

Pipe Line Development Co.
5700 Detroit Avenue Cleveland 2, Ohio

coating), line-up, make stringer bands and move ahead determines the progress of the job.

The welder on firing line and the crew making field joints over welds find the wide-cut ditch easy to move around in.

Cutting the ditch wide has also helped in the backfill operation. The fill is made using a "drag-plate" to pull the burm over into the ditch, where it flows freely in and around the pipe, with no bridging, and surprisingly enough, a smooth pad with no left over.

Less Right-of-Way

Another big advantage of the construction method being employed is that less right-of-way width is required. Unlike the customary method, where pipe is worked to the side of the ditch, the bell hole method needs only a minimum in which to string pipe and allow room for equipment movement to the side for lowering-in. Widths currently needed are about 55 ft.

Loops Increase Capacity

The 47 miles of 36-in. being laid is a part of Transcontinental's "Sun" loop program designed to bring its system's capacity up to the 560,000,000 cu ft daily as authorized by the FPC. Total loop mileage includes 10.37 miles of 30-in. in Louisiana between the Atchafalaya and Mississippi Rivers.

The 36-in. loops are split into three parts—27.79 miles near the company's Tylertown, Mississippi, station, 14.74 miles near Billingsley, Alabama, and 4.15 miles on the west side of the Coosa River, just west of station 10. Terrain in Mississippi is rolling while that in Alabama is very hilly.

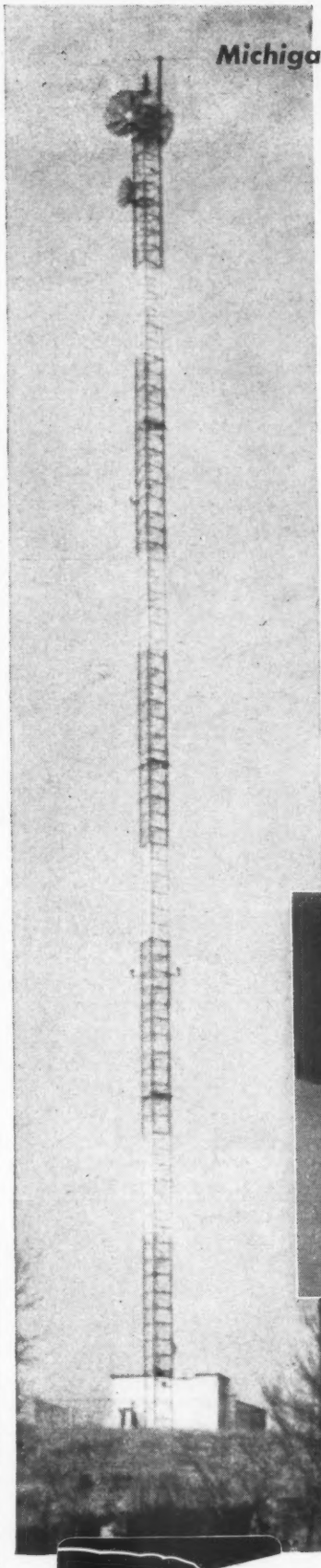
First Pipe of Its Size

The 36-in. line pipe used on the main line has a wall thickness of .406-in. and weighs 156 lb per lineal ft. Pipe used at highway and railroad crossings is .469-in. and weighs approximately 180 lb per lineal ft. Casings for the highway and railroad crossings are 40-in. diameter. All pipe, first of its size made for main line use, is API 5LX52 expanded, produced at the Orange, Texas, plant of Consolidated Western Steel, a U. S. Steel subsidiary. It was loaded on barges at Orange and shipped through the Intracoastal Canal to the convenient unloading points in Mississippi and Alabama. Pipe was supplied in 40 ft lengths.

Operating pressures on the discharge side of compressor station 10 into the 36-in. will be 800 psi. Pressure on the Alabama loops will also be 800 psi.

Pipe Protection

Pipe protection includes cleaning, priming, a 5/32-in. enamel coat (as-



Michigan-Wisconsin Pipeline Company

Assures power for repeater stations with ONAN Standby Electric Plants

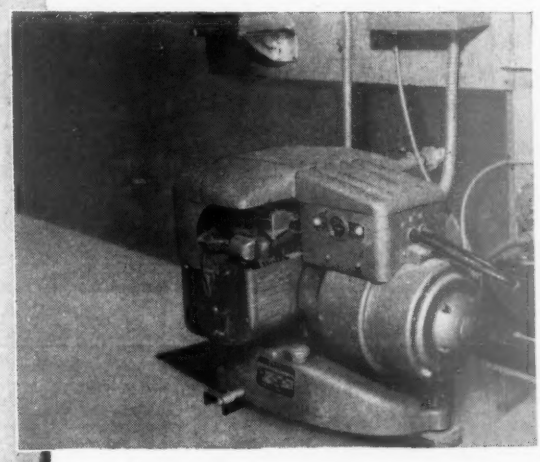
Microwave radio handles communications for the Michigan-Wisconsin pipeline which carries natural gas from Texas fields throughout Wisconsin and Michigan.

Of the 60 repeater stations in the system, 53 are unattended and are equipped with Onan Standby Electric Plants and Onan Automatic Line Transfer Controls. When commercial power is interrupted, the Onan plants start automatically and supply power for operating microwave equipment.

Most of the Onan units are Model 305CK electric plants of 3,500-watt capacity. This model, together with the Onan 5 and 10KW "CW" electric plants have built-in advantages for microwave standby service. They are air-cooled, extremely compact, and dependable.

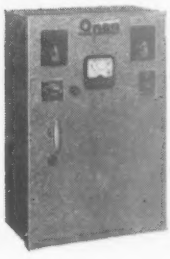
If you have a problem in standby power, write our sales engineers. Onan builds electric plants for every need . . . from 400 to 55,000 watts.

Onan Model 305CK shown installed in the repeater station at Waukesha, Wisconsin. Bottled gas is used for fuel.



NEW AUTOMATIC MICROWAVE LINE TRANSFER CONTROL

This new control facilitates testing of all control components as well as the engine generator set. Momentary contact switch transfers load from commercial power to the generating plant with only 1/10th second interruption. Generator can be exercised by itself if desired. Control incorporates time-delay starting, stopping Voltage sensitive relays, both on the commercial line and on generator output, assure correct voltage before transferring load.



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Pipeliners for over 36 years

Many years and much experience separate the early Buckeye, pictured above ditching for a 6" screw pipeline layed by Oklahoma in 1922 . . . and the modern Buckeye, pictured at right cutting ditch on one of Oklahoma's recent 30" spreads.

As pipelines have grown from the low pressure screw pipe of 1918, to the "Big Inches" of 1954, Oklahoma's techniques have progressed from hand tools and mule power to employ the best in pipe laying equipment with experienced and efficient personnel . . . an essential combination for delivering high quality work under any conditions.

OKLAHOMA PIPE LINE CONSTRUCTORS

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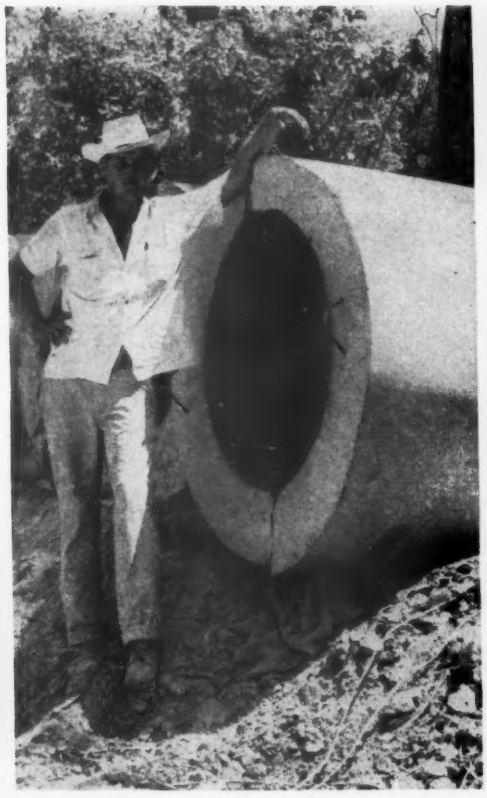


Coating (left) is checked and patched on right-of-way before joints are lowered in. Pipe is yard coated and wrapped. Size comparison (center) of river weights is given by pipeliner beside one of them. Specially fabricated of concrete, they weight 7500 lb. Protection at bare ends of pipe joints after welding (right) is given through use of asphalt impregnated felt field jointers. Annulus space of about ½-in. is filled with enamel, open space at top covered with paper to protect against dirt.

phalt base) and glass fiber and felt paper wraps. At all highway and railroad crossings, test leads are installed by company corrosion engineers.

Welding is regular stovepipe method in the ditch. All welds are checked radiographically.

At the tie-ins for the loop lines and at valve locations, full opening gate valves are being installed to allow scraper passage.

Stream Crossings

Stream crossings on the loop lines use regular line pipe, with river weights used on approaches and in stream bed. Weights used on the approaches are square with a half round cut, weigh approximately 7900 lb each.

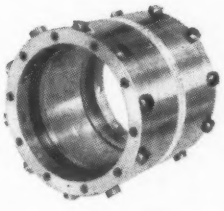
Weights used in the stream bed, weigh approximately 7500 lb each. All weights are reinforced concrete, for which forms were specially fabricated in Houston, and are poured on the jobsite.

Associated Pipe Line Contractors, Houston, is general contractor for the project. J. O. (Red) Willett, subbed the stringing, Industrial X-Ray subbed the radiographic inspection, and Rosson-Richards subbed the yard-coating and wrapping. Chief personnel on Associated's Mississippi spread are Emmitt Singleton, superintendent, and Ray Isgitt, office manager.

Transcontinental personnel on the project include A. L. Barnett, chief inspector; Joe Hickman, welding inspector; C. M. (Joe) Isaacs, lowering-in inspector; C. E. Schorre, coating inspector; Luther Walters, clean and grade and clean-up inspector. At the Lexie coating yard, R. L. McIntyre is engineer and inspector.

* * *

Weld+Ends Permits Welding a Pipeline While Pumping Through It.



A pipeline safety welding coupling for crude oil, gas, gasoline, asphalt, steam, chemical process and other pipelines. WELD+ENDS joins pipe securely so flow can be resumed immediately at full pressure. Welding can be performed while pipeline is in use days or weeks later. Sizes 2" to 30".

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Pipe Line Projects

Weather Plagues Pembina Line, Underway Anyway

Plagued by the wettest summer weather in many years in the whole of northern and central Alberta, the Pembina Pipe Line Company Limited has finally been able to launch construction of its 72-mile 16-in. crude oil pipe line from Drayton Valley to Edmonton. Ultimate capacity of the line will be 150,000 bbl daily, but initial daily throughput will probably be less than 10,000 bbl. Scheduled completion date is November 15, subject to possible further delays due to weather.

The economic significance of construction of this line, planned last winter, and which received a permit from the Alberta authorities several months ago, is that it will provide an outlet for the province's largest single oil reserve, giving it access alternately to the Interprovincial or the Trans Mountain pipe lines. It will also relieve the drastically curtailed production of this summer, when for several months practically no oil could be moved out of the field because of impassable roads due to continuous rain and muddy ground.

First With Big Inch Smooth Bends . . . In Performance!

. . . The CINCH Pipe Bender

Features for Greater speed and Easier handling:

- Automatic Hydraulic Wedge-Type Pin-Up Slide
- Extra Large Piston Rams and Return Oil Lines
- Hydraulic Lift Tongue and Tulsa Winch
- Athey Tracks (optional)

There's no better method for bending pipe smoothly and evenly than with hydraulically exerted cold compression as provided by The Cinch Bender. Contractors agree that Cinch provides speed, economy, and safe pipe bending right on the job. So—

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PIPELINE EQUIPMENT, Inc.

Shell Building Short Montana Crude Line

Shell Pipe Line has awarded a contract and construction is underway on a 36-mile, 12-in. crude pipe line in the Baker-Glendive area in Montana. Contract was awarded to Anderson Brothers, Houston, Texas.

Platte Completes Expansion, System Capacity Raised

With the completion of the Bosworth, Missouri, pumping station, the last 4 recently constructed stations, Platte Pipe Line Company has boosted its capacity to 192,500 bbl daily from the Rocky Mountain area to Eastern markets. At present the line is handling 160,000 bbl per day. The added capacity has eliminated the necessity of prorating shippers. This line is currently handling 4 grades of crude oil —general sour, intermediate sour, asphalt sour, and sweet.

South Central NACE Regional Meet Scheduled For Dallas

Six symposia of technical papers and two discussion programs will feature the October 12-15 meeting in Dallas, Texas, of the NACE South Central Regional meeting. Symposia topics include cathodic protection, protective coatings, inhibitors, and pipe line corrosion.

Straits Crossing Film Available From M-C&S

A narrative color film recording the construction of two crude oil transmission lines beneath the four-mile-wide Straits of Mackinac—the longest and deepest underwater pipe lines ever attempted by "pull" method—has been produced by Merritt-Chapman & Scott and is now available for use upon request by writing Merritt-Chapman and Scott, Dept. F, 260 Madison Avenue, New York, 16, or 1648 Standard Building, Cleveland, Ohio.

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Rock, mud, swamp, mountains—there's nothing easy about laying a pipeline, but they can make it really rough! Our rugged, experienced spreads working with ingenuity and the right machines push ahead to the earliest possible completion date.

We can lay your line anytime—in the heat of summer or the cold of winter; anywhere—through rock and dust or mud, swamp or mountains. From the top men to the clean-up men of Panama-Williams, our determination is to lay your line the way you want it. Call us.

PANAMA-WILLIAMS COMPANY

PIPELINE CONTRACTORS

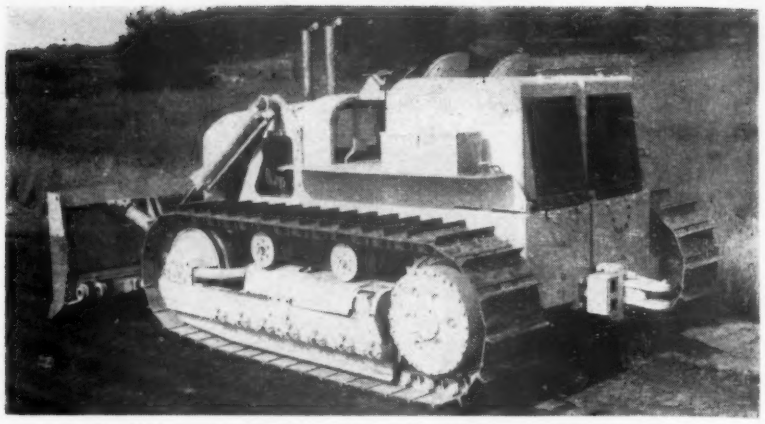
HOUSTON

Shell Pipe Line Sells Facilities to Cherokee

Shell Pipe Line Corporation has sold approximately 229 miles of pipe line facilities in Oklahoma and Kansas to the Cherokee Pipe Line Company.

The new properties consist of 2, 4, 6, and 8-in. crude trunk and gathering lines north of Tonkawa, extending to Elyria, Kansas.

Sale does not affect Shell Pipe Line's operations at their Tonkawa station or gatherings in the Lucien, Perry, Ceres, and Billings fields between Tonkawa and Cushing. Final release of properties will be on or before November 1.



Euclid's model TC-12, twin engine, 380-hp crawler tractor.

Euclid Enters Tractor Field With 380-hp Crawler Model

The Euclid Division of General Motors has entered the crawler tractor field with a new twin-engine machine of new design as its first model. Powered by two 190-hp 6-cylinder diesel engines through torque converters and a Torqmatic transmission, each drive train independently powers one track. Named model TC-12, the tractor is designed to provide higher power-to-weight ratios. It was designed for an average travel speed of 2½ mph. Top speed is 8 mph. A steering feature is the method of sharp turning, accomplished by putting one track forward gear, the other in reverse. It weighs 53,000 lb bare.

Oklahoma Line Loop Planned By Cities Service Pipe Line

Construction is to get underway soon on a 23-mile, 8-in. loop between Hewitt and Tussy, Oklahoma, by Cities Service Pipe Line Company. The crude line loop will enable the company to segregate sour and sweet crudes for transportation over the new Cherokee system.

El Paso-Albuquerque Line Underway Soon

Plans for a 248-mile, 6-in. products pipe line from El Paso, Texas to Albuquerque, New Mexico, have been completed by Standard Oil of Texas, a wholly owned subsidiary of Standard Oil of California. Construction of the $4,000,000 line is expected to get underway by November 1. Date of completion has been set for March 1, 1955. Initial capacity will be 5000 bbl daily, which can be boosted to 11,000 bbl per day through addition of another pump station. The line will handle aviation gasoline, housebrands, kerosine, and diesel oil. The company has applied to ODM for a rapid tax write-off certificate.

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Why continue to throw away profits? The Enardo Vapor Control system can cut your losses enough to pay for installation of the system as well as reconditioning all storage tanks on an average lease.

Enardo Vapor Control equipment has been field tested and proven. The hatches are of either dead weight or spring-loaded manufacture. The vent line is connected to the hatch by means of a by-pass containing an automatic check valve. When the tank hatch is opened for gauging or thiefing, it seals off the vent line, and isolates that tank from the remaining tanks in the battery, cutting vapor losses to the minimum.

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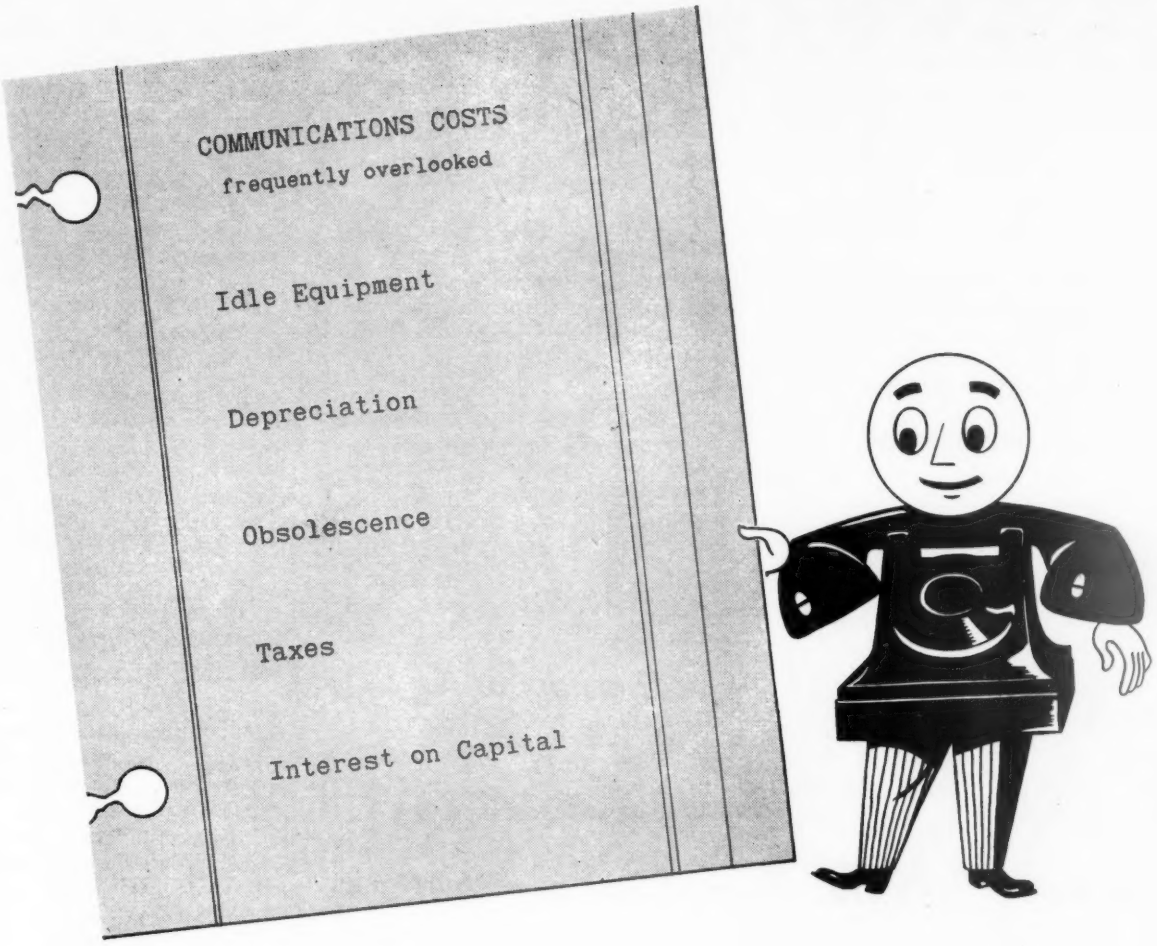

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Projects

Oklahoma Crude Line Underway By Conoco

Continental Pipe Line Company has awarded contract to G. G. Griffiths Construction Company, Tulsa, to construct 64 miles of new 12-in. crude oil pipe line from Ogg Station near Tonkawa to Oklahoma City, Oklahoma.

The 64-mile line, combined with 18 miles of 12-in. loop constructed 2 years ago, will give Conoco a complete 12-in. crude oil line from Wichita Falls, Texas, to Ponca City, Oklahoma. It will enable the company to release about 82 miles of 8-in. from Ogg Station to Oklahoma City, which has been sold to Cherokee Pipe Line Company for conversion to a products line as part of a 582-mile products line from Ponca City to Wood River, Illinois.

Service Moves Offices To Pauls Valley Location

Healdton district headquarters of Service Pipe Line Company have been moved to Pauls Valley, due to increased pipe line activity in that area. J. J. Ashley, district superintendent, will move to the new headquarters.

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Wherever It Goes...

PARKHILL Knows...

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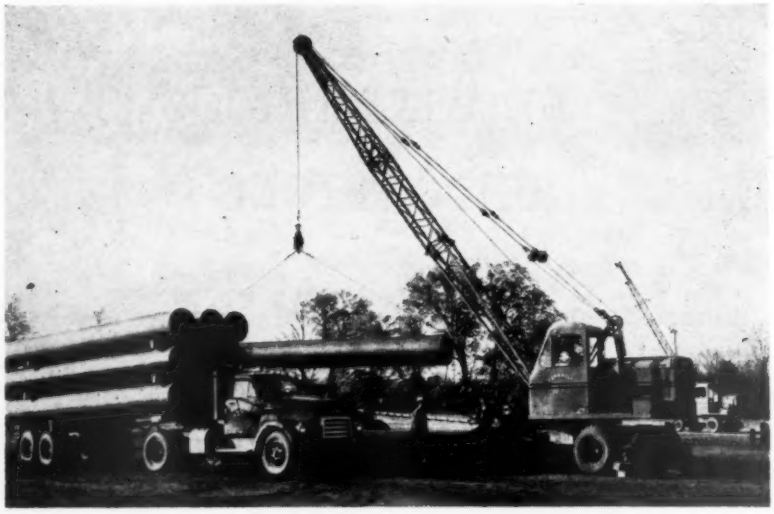

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FPC Okays 6405 Miles During 12-Month Period

In the year ending June 30, 1954, construction of 6405 miles of natural gas pipe line was authorized by the FPC, the government agency has reported. Estimated cost of those facilities is $500,881,248.

During the first 6 months of 1954, the agency authorized approximately 4500 miles—70 per cent of the 12-month total—at an estimated cost of $324,500,000. An aggregate 251,540 hp was approved during the 12-month period for compressor units. The new facilities will provide service to 56 cities of 50,000 population or over in 14 states as well as numerous smaller communities, and will add 1.75 billion cubic feet daily to capacities.

Interstate Oil Pipe Line Planning Mississippi Lines

Interstate Oil Pipe Line Company has announced plans to construct approximately 32 miles of 8-in. crude oil pipe line. Line will extend from Interstate's installations in the Gwinville field of Jefferson Davis County, Mississippi, to the Soso field located in the tri-county area of Jones, Jasper, and Smith counties, Mississippi.

Upon completion, the line will provide pipe line service for production in the Soso field. Crude from this field has been transported by truck to interstate's Gwinville station. The project will extend Interstate's Mississippi system northeastward through Jefferson Davis and Covington counties, terminating in the Jones County area of the field.

Cherokee System Plans 83-Mile Jet Fuel Line

Plans for an 83-mile gasoline and aviation jet fuel pipe line from Ponca City refineries of Continental Oil Company and Cities Service Company to the government's Wichita, Kansas, Air Force Base have been announced by Cherokee Pipe Line Company.

Cherokee has also purchased from Shell Pipe Line Company a crude oil pipe line, including both trunk lines and field gathering systems, extending from Tonkawa, Oklahoma, to Elyria, Kansas.

A 75-mile portion of the Shell line will be converted to the gasoline and jet fuel system from Ponca City to Wichita. Construction of 8 miles of new line will be required to complete the system to Wichita. The balance of the crude system will be tied into Continental Pipe Line Company's Kansas system extending to Ponca City.

Another of HILL, HUBBELL's "Things That Money Can't Buy."

"Practice makes perfect" is an axiom proved by the many Hill, Hubbell men who have been "on the job" for years and years—gradually acquiring a know-how that spells the difference between superior and mediocre results. Add the years of their executive and supervisory experience together! You get a total which explains, in part, the unquestioned leadership of America's "pioneers in pipe protection."

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Projects

Western Pipe Line 628-Mile Construction Kicks Off

Construction of Service Pipe Line Company's 628-mile crude oil pipe line between Fort Laramie, Wyoming, and Freeman, Missouri has begun with work underway simultaneously at several locations.

The 20, 22, and 24-in. line will service oil producers of western Kansas, the Rocky Mountain Region, Wyoming, and the Denver-Julesburg Basin.

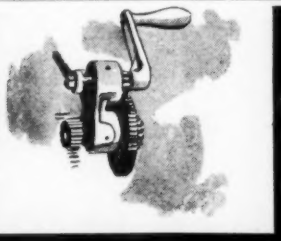
Contractors for building the line are O. R. Burden Construction Corporation, Tulsa, Oklahoma and H. B. Zachry Company, San Antonio, Texas, J. L. Cox and Son, Raytown, Missouri, Parkhill Trucking Company, Tulsa, and John Bunning Transfer, Rock Springs, Wyoming, will string the pipe.

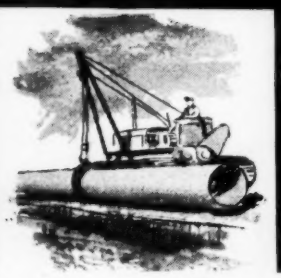
Ohio Fuel Gas Plans New Pipe Line Facilities

Ohio Fuel Gas Company has filed an application with FPC requesting authorization for the construction of 9 projects consisting of about 28 miles of new pipe line and a 140-hp compressor unit at an existing station on its natural gas system in Ohio.

a precision instrument

H & M Pipe Cutting and Beveling Machines are designed and manufactured to high engineering standards. Close tolerances in gear design consistently give cleaner, more accurate cuts, yet the H & M is rugged and will withstand years of tough field use.





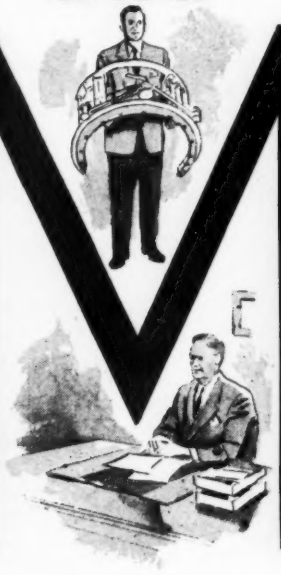
for pipe cutting and beveling

A complete line of beveling machines is available from H & M. The #1 machine will cut and bevel pipe as small as 4", the #5 machine will handle a diameter of 36". Once in place the entire 360° cut can be made in a matter of minutes with an effortless turn of the hand crank.

and

now lightest in its class

A new metal manufacturing process has recently made the H & M the lightest beveler in its class . . . has actually reduced the weights of the number 3, 4, and 5 machines by 40%. Think of what this means in the field—new lightness without any loss of durability.



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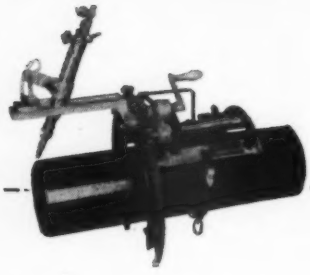
Point for point the H & M gives you more. It is actually possible to save one-half your labor and gas cost by using the H & M Pipe Cutting and Beveling Machine. Attachments are available for out-of-round and shape cutting. For more information, write H & M.



H&M PIPE BEVELING MACHINE COMPANY

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Sunray Buys South Texas Pipe Line System

Sunray Oil Corporation has purchased the Ed Scurlock Pipe Line Company and all facilities serving the Victoria, Texas, area, and the 55 miles of crude gathering lines will become a part of the Sunray Coastal Pipe Line Company gulf coast pipe line transportation facilities of approximately 100 miles. The combined lines are currently gathering approximately 20,000 bbl of selected high quality crude per day.

Longest Offshore Line Planned For Louisiana

Magnolia Petroleum Company, Continental Oil Company, and Newmont Oil Company confirmed plans for construction of the world's longest undersea pipe line, to be laid in the Gulf of Mexico off the coast of Louisiana.

The three companies, which operate as a team in Louisiana-Gulf offshore areas, have awarded a contract for the project to Brown and Root of Houston to lay the 48-mile undersea gathering line from Burns Terminal on the coast of St. Mary's Parish, Louisiana, out into the Gulf of Mexico to Block 126 Eugene Island oil field, most distant offshore oil discovery in the Continental Shelf, 25 miles from the nearest land. Upon completion, the line will be operated by Magnolia Petroleum Company.

Designed to carry both crude oil and gas from offshore fields, line will run in a dog-leg pattern out from the Louisiana shore to Blocks 45-51 Eugene Island field area, where both oil and gas are produced, and on out to Block 126 oil field area.

First phase of the line extending to Blocks 45-51 will be completed this year and the rest of the construction will be finished around the middle of next year.

The line will have an ultimate capacity of transporting some 50,000 bbl per day ashore. When the project is completed, offshore oil and gas will move into the Burns Terminal where it will be separated. Gas will be sold to a gas transmission company and the oil will be stored and then transported to refining centers in the Gulf Coast area.

FPC Okays 46-Mile Line, Station For Ohio Fuel Gas

Ohio Fuel Gas Company, of Columbus, Ohio, has received temporary FPC approval for the construction of a total of about 46 miles of pipe line and 3000 additional compressor horsepower on its natural gas transmission system in Ohio.

XUM

NOW you can operate small valves economically & safely

with Limitorque® REMOTE CONTROL

The new SMA-00 and SMA-000 LimiTorque Valve Control is the latest and most advanced method of operating small valves, ranging from 1½" up to 8" in diameter. These units provide complete safety to workmen, by eliminating the need of climbing to high or hazardous locations for manual valve operation. The valve operating parts are protected by two limit switches ...One provides uniform valve seating thrust, giving positive protection to the parts from overload. The second switch is the geared limit, which controls the stem travel for both directions.

SMA-00 and SMA-000 LimiTorque Valve Controls offer an extremely economical, and simple method of motorizing smaller valves. These Operators can be readily applied to all types of Valves: Gate, Globe, Plug and Butterfly . . . and may be had to actuate by a wide range of power sources including Electricity, Hydraulic Pressure, Natural Gas or Air.

For full details and information regarding these new LimiTorque Valve Controls, write for latest Bulletin.

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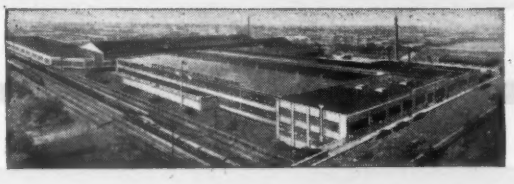


Industrial Gears & Speed Reducers

LimiTorque Valve Controls

PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
CRUDE LINES				
Arapahoe Pipe Line Company	319	18	Merino, Colorado, to Great Bend, Kansas	R. H. Fulton
Arapahoe Pipe Line Company	175	20	Great Bend to Humboldt, Kansas	Fulton & Panama-Williams
Cheyenne Valley Pipeline Company	58	10	Lance Creek to Fort Laramie, Wyo.	Planned
Cities Service Pipe Line Co.	23	8	Loop on Hewitt-Tussy Line in Oklahoma	Underway
Continental Pipe Line Co.	64	12	Tonkawa to Oklahoma City, Oklahoma	G G. Griffis Company
Continental Pipe Line Company	58	8	Sussex to Glenrock, Wyoming	Proposed
Interprovincial Pipe Line Co.	129	24	Edmonton to Alberta-Saskatchewan Border	Mannix, Ltd.
Interprovincial Pipe Line Co.	201	24	South Saskatchewan River to Gretna, Manitoba.	Anderson International
Interstate Oil Pipe Line Co.	32	8	Gwinville field to Soso field, Mississippi	Proposed
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan	Proposed
Lakehead Pipe Line Co.	153	26	Loops on present line	R. H. Fulton & Company
Lakehead Pipe Line Co.	51	26	Loops on present line	Anderson Brothers
Magnolia Pipe Line Company	48	12	Offshore line, Burns Terminal, Louisiana to Block 126 in Gulf	Brown and Root (Joint venture with Conoco, Newmont)
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan	Proposed
Minnesota Pipe Line Co.	250	16	Clearbrook to Hastings, Minnesota.	Williams Brothers
Mid-Saskatchewan Pipelines, Ltd.	24	8	Smiley Kerrobert, Saskatchewan, Canada.	Planned
NNCW Pipe Line Co.	127	8-10	Western County to Casper, Wyoming.	Planned
Orchard Pipe Line	45	8	Orchard to Merino, Colorado.	Proposed
Pembina Pipe Line Company, Ltd.	325	3-12	Gathering system in Pembina field	Mannix, Ltd
Pembina Pipe Line Company, Ltd.	72	16	Pembina field to Edmonton, Alberta	Mannix, Ltd
Powder River Pipe Line Company	436	10-16	Williston Basin to Laure and Billings, Montana	Proposed
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.	Planned
Roosevelt Oil & Refining Corp.	22	4,6	St. Helen to Norwick, Michigan.	Planned
Service Pipe Line Company	21	8-10	Near Tioga, North Dakota.	C. P. Bartley and Son
Sinclair Pipe Line Company	31	12-16	Monee to Lemont, Illinois	Proposed
South Saskatchewan Pipe Line Co.	155	16	Fosterton to Regina, Saskatchewan, Canada.	Fulton-Bannister
Trans Mountain Oil Pipe Line Corp.	26	16-20	Canadian border to Ferndale, Washington.	Engineers Ltd.
Trans Mountain Oil Pipe Line Corp.	27	20	Laurel Junction to Mt. Vernon, Washington.	Planned for 1955
Union Oil Company	65	12	Santa Clara Field to Wilmington Refinery.	Planned
U. S. Navy	450	8	Fairbanks to Gubik Gas field, Alaska.	Proposed
West Coast Pipe Line Company	960	20-22	Wink, Texas to Norwalk, California.	Planned
Western Pipe Line Company	630	20-22-24	Fort Laramie, Wyoming, to Freeman, Missouri	H. B. Zachry & O. R. Burden
PRODUCTS LINES				
American Pipe Line Company	1910	8 to 26	Beaumont, Tex., to Newark, New Jersey, with laterals.	Proposed
Badger Pipe Line Company	215	8-10-12	East Chicago, Indiana to Madison, Wisconsin.	Morrison Construction Co. has Chicago area section
California-Oregon Pipe Line System	103	6	Crescent City, California to Medford, Oregon.	Proposed
Cherokee Pipe Line Company	83	8	Ponca City, Oklahoma, to Wichita, Kansas, jet fuel line (8 new miles construction, 75 conversion)	Planned
H. W. Bass & Sons, Incorporated	152	4-6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas.	Proposed
Bell Oil and Gas Company	140	6-8	Ardmore to Cushing, Oklahoma	Planned
El Paso Natural Gas Company (LPG Line)	119	3-6	Bloomington to Gallup, New Mexico	Planned
Goliad Corporation (LPG Line)	117	4-6	Kittie Plant to Corpus Christi, Texas	Planned
Great Lakes Pipe Line Company	83	12	Alexandria to Rosedale, Minnesota.	R. H. Fulton
Great Lakes Pipe Line Company	80	12	Rosedale to Rosemount, Minnesota.	Associated
Inland Corporation	22	6	Springfield to Dayton, Ohio	Planned
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota.	Proposed
Mayflower Pipe Line Company	—	—	New Jersey refineries to New England points.	Proposed
Oil Basin Pipe Line Company	230	8	Laurel, Billings to Glendive, Montana.	Midwestern
Phillips Petroleum Company	54	6	Goldsmith to Borger, Texas.	Planned
	52	10	Shell's Brookshire system to Sweeny, Texas.	Planned
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas.	Planned
Shell Pipe Line Corporation	65	12	Baton Rouge, Louisiana to Norco Refinery.	Houston Contracting Company
Standard Oil of Texas	250	6	El Paso to Albuquerque	Planned
Sunflower Pipe Line Company	265	3-6	Kearny, Grant and Haskell counties to Wichita, Kan.	Planned
Triangle Pipe Line Company	560	12	Arkansas City, Arkansas, to Covington, Kentucky.	Proposed
United States and Canadian Govts.	600	8	Haines to Fairbanks, Alaska.	Underway
U. S. Army	600	—	Network of products lines in Spain to serve military bases.	Planned
Wyoming-Nebraska Pipeline Company	215	6	Cheyenne, Wyoming, to North Platte, Nebraska.	Houston Contracting Co.
GAS LINES				
Alabama-Tennessee Natural Gas Co.	25	8-12	New lines in Alabama, Mississippi	Proposed
American-Louisiana Pipe Line Company	1120	22 & 30	Lowry, Louisiana to De'roit, Michigan.	Proposed
Arkansas-Louisiana Gas Company	136	8⅝ to 24	Nine Loops on System.	Approved
Arkansas-Missouri Power Company	140	2 to 10	St. Francis River, Clay County, Ark. to Campbell, Mo.	Planned
Associated Natural Gas Company	88		Missouri.	Proposed
Central Hudson Gas and Electric Company	48	12	TGT line to Kingston, N.Y.	Proposed
Cities Service Gas Company	18	16	Lawrence and Newton Counties, Missouri.	
Cities Service Gas Company	24	26	Franklin and Johnson counties, Missouri.	Approved
Cities Service Gas Company	9	20	Cherokee and Jasper counties, Missouri.	Approved
City of Fayette, Alabama	20	5	Fayette, Ala. to Southern Natural's system.	Proposed
City of Dallas, Georgia		8, 4½	Distribution system.	Engineering-Construction Company, 1954
Coast Counties Gas Electric Company	40	3, 4 & 8	Coast and Valley Region, California.	Planned
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado.	Approved
Colorado Interstate Gas Company	243	4 to 20	Colorado, Oklahoma, Texas, and Kansas.	Engineering-Construction and Z. J. Graham
Colorado-Western Pipeline Co.	328	16-18	Ignacio field to Pueblo and Denver	Approved
Continental Oil Company, (Agent)	—	—	Gas gathering system in Washington and Adams counties, Colorado.	Planned by operators of Little Beaver and Badger Creek fields
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia.	Proposed
El Paso Natural Gas Company	74	—	Additions in Texas, New Mexico and Arizona.	Proposed
El Paso Natural Gas Company	13.3	—	Lea county, New Mexico.	Planned
El Paso Natural Gas Company	32.5	10	Reagan county to Upton County, Texas.	Approved
Fort Worth Basin Gas Company	—	—	Novice, through Brown and Comanche Counties, Tex.	Planned
Gulf Interstate Gas Company	329	12-24	Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line.	Proposed
Home Gas Company	32	12	Breesport to Union Center, New York.	Planned
Home Gas Company	22	12-16	Binghamton, New York.	Underway
Hope Natural Gas Company	22½	12	Boone and Logan Counties, W. Va.	Approved
Interstate Power Company	26	8	Hooppole, Illinois to Clinton, Iowa.	Proposed
Iroquois Gas Corp.	24½	20	Erie County, New York	Underway
Kansas-Nebraska Natural Gas	41	10	Albion, Arcadia, and Broken Bow, Nebraska.	Approved
Kansas-Nebraska Natural Gas	37	2-3	Gathering lines in Colorado.	Approved
Kansas-Nebraska Natural Gas	66	—	Gathering lines in Denver-Julesburg area.	Approved
Kansas-Nebraska Natural Gas	40	—	Gathering lines in Hugoton field in Kansas.	Approved
Kansas-Nebraska Natural Gas	13	—	Gathering lines in Guymon field of Oklahoma.	Approved
Lateral Gas Pipe Line Co.	27	—	Grant, Clarinda and Villisca, Iowa.	C. E. Wilson Constr. Co.
Llano Grande Corporation	130	2-26	Cochran County, Texas	Panama-Williams
Manufacturers Gas Light & Heat	40		Allegheny, Washington, and Beaver Counties, Pa.	Proposed

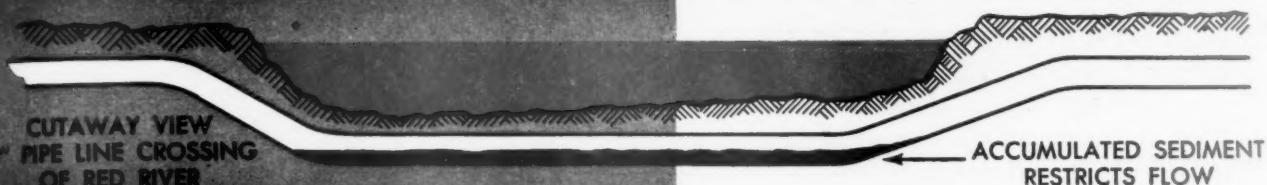
XUM

Know-how and Equipment

SOLVE A PIPELINE PROBLEM

1st OF A SERIES

1 Due to excessive pressure drop in this Red River crossing, management knew there must be considerable restriction in this section, probably accumulated silt, rust and scale, which must be removed to increase flow.



2 Williamson engineers were asked to help solve the problem, quickly and economically. They developed a special Pig which could safely traverse pipe half-filled with silt, rust and scale, removing a portion of the accumulation with each run, thus preparing the line for routine cleaning with "WC" Pigs.

3 This special Pig was built and tested in Williamson's completely equipped laboratory by engineers experienced in pipeline operations.

4 Williamson's representative, a factory-trained engineer, was on hand when the river crossing was cleaned. He assisted in preliminary pigging with the special Pigs and final clean-up with the "WC" Pigs. As a result of this operation, flow conditions returned to normal, and throughput was increased.

These same services are available to all pipelines at no extra cost.

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Bartlesville, Okla.
E. O. (Steve) Owens

Baton Rouge, La.
Jack Pelkey

Buenos Aires, Argentina
Kenneth J. Langley
Jose Ovidio Martinez

Edmonton, Alberta
A. L. Crumback
Al Grieg

Houston, Texas
Tod Pazdral
James McBrien

Joliet, Illinois
Floyd Zangler

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PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
Manufacturers Gas Light & Heat	61	3 to 16	Various points on system in Pa., West Vir. and Ohio.	Approved
Manufacturers Gas Light & Heat	72	16-20	Doddridge, Wetzel and Marshall Counties, West Vir.	Approved
Michigan Consolidated Gas Company	25.5	12	Sparta to Muskegon, Michigan.	Planned
Michigan-Wisconsin Pipe Line Company	252	4-24	Loops and stations in Illinois.	Planned
Mid-South Gas Company	68.6	—	lines to serve eight Arkansas communities	Proposed
Mississippi River Fuel Corporation	190	10-18	Laterals in Woodlawn and Waskom gas fields, Tex.	Planned
Montana-Dakota Utilities Co.	4	—	Lines and 2640 hp station in Big Horn County, Mont.	Approved
Montana-Dakota Utilities Co.	49	—	Loops in Montana, Wyoming, South Dakota	Approved
Montana-Dakota Utilities Company	56	—	Hettinger and and Stark Counties, North Dakota	Approved
Montana Power	52	16	Canada-Montana border to Cut Bank, Montana.	Planned
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky.	Planned
Natural Gas Pipe Line Co. of America	240	24	Carter—Garvin and Stephens counties, Okla., to Hutchinson county, Texas	Planned
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado.	Planned
New River Gas	50		Sumners to Monroe counties, West Vir.	Planned
Niagara Gas Transmission, Ltd.	78	20	Lewiston Bridge to Sheridan, Ontario	F. E. Shaw-Conyes Constr.
North Dakota Natural Gas Company	475	6-12	Statewide system in North Dakota.	Planned
Northeastern Gas Transmission	22	8	Upton, Massachusetts to Pawtucket, Rhode Island.	Planned
Northern Indiana Fuel Light	35	8	Edgerton to Alburn, Indiana.	Planned
Northern Natural Gas Company	74	20-24	Paullina, Iowa, to Sioux Falls, South Dakota	R. H. Fulton
Northern Natural Gas Company	93.5	20	Ogden to Waterloo, Iowa	Hallmac Constr.
Northern Natural Gas Company	90	16	Waterloo to Dubuque, Iowa	Engineering-Construction
Northern Natural Gas Company	6	10-16	Cherokee, Iowa, to Sioux Falls, South Dakota	G. G. Griffis
Northern Natural Gas Company	330	2-12	System in South Dakota	Proposed
Northern Natural Gas Company	310	24	Lines in North Dakota	Proposed
Northwest Alabama Gas District	40	9	Southern Natural's line to Haleyville, Alabama.	Certified
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada.	Planned
Ohio Fuel Gas Co.	28	—	Loops in Ohio	Proposed
Ohio Fuel Gas	74	3 to 20	Hocking, Knox, and Ashland counties, Ohio.	Planned
Ohio Fuel Gas	47	20	Benton Township, Hocking County, to Columbus, Ohio.	Approved
Ohio Fuel Gas	69	20-24	Lines to tie in Gulf Interstate line along various points in Ohio.	Proposed
Ohio Fuel Gas	24½	20	Richland and Crawford Counties, Ohio.	Approved
Ohio Fuel Gas	46	—	New Lines in Ohio.	Proposed
Pacific Northwest Pipeline Corp.	1466		Ignacio, Colorado, to Bellingham, Washington.	Approved
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho to Yakima, Washington.	Proposed
Panhandle Eastern Pipe Line Co.	125	—	Tuscola, Ill. to Mich.-Wis. Pipe Line connection.	Planned
Panhandle Eastern Pipe Line Company	295	30	Loops on existing system	Approved
Panhandle Eastern Pipe Line Company	97	—	lateral lines	Proposed
Panhandle Eastern Pipe Line Company	178	—	gathering lines in Hugoton field and Andarko basin. (includes 8 field compressor stations).	Proposed
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine.	Planned
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York.	Proposed
Shenandoah Gas Company	39	3-4-8	Middleton Virginia, to Martinsburg, West Vir.	Proposed
Signal Oil & Gas	90	2-24	Gathering system near Tioga, North Dakota	Sheehan Constr. Co.
South Georgia Natural Gas Company	368	2-12	Phoenix, Alabama to Tallahassee, Florida.	Approved
Southern Natural Gas Co.	110	18	Loops on southern line.	Williams Bros
Southwest Gas Corporation, Limited	26	—	From P.G. & E. line to Victorville, California.	Proposed
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut.	Planned
Tennessee Gas Transmission	67	30	Loops in Texas and Louisiana.	Approved
Tennessee Gas Transmission	58	20	Louisiana Gulf Coast to near Kinder, Louisiana.	Approved
Tennessee Gas Transmission	100		Laterals in Texas.	
Tennessee Gas Transmission	45	20	Buffalo, New York to the U. S.-Canadian border, Hamburg station near St. Catherines.	Approved
Texas Eastern Transmission	58	16-20	Joaquin to Longview, Texas.	Proposed
Texas Gas Transmission Corporation	48	26	Loops on Memphis-Slaughter line.	Planned
Texas Gas Transmission Corporation	24	16	South Louisiana gas fields.	Houston Contracting Co.
Texas-Illinois Nat. Gas. Pipe Line	—	30	Approaches to aerial river crossing, Grand Tower, Illinois	Ray L. Smith and Son, Inc.
Transcontinental Gas Pipe Line Corp.	421	30-36	Loops on Texas-New York main line.	Planned
Transcontinental Gas Pipe Line Corp.	57	—	Louisiana, Mississippi, and Alabama.	Associated Contractors
Transcontinental Gas Pipe Line Corporation	25	12	Cameron and Calcasieu Parishes, Louisiana	Proposed
Trans-Canada Pipe Lines, Ltd.	2247	14-36	Alberta area to Toronto, Montreal	Engineering Underway
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton	Proposed
United Fuel Gas	50	20-24	Wood County to Hanham, West Virginia.	Fulghum
United Fuel Gas	32	24	Near Ripley, West Virginia to Lanham station, Putman County, West Va.	Proposed
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania.	Planned
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah.	Planned
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.	Proposed
Warren Petroleum	54	4-30	Lea County, New Mexico.	Planned
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston County, Wyo.	Planned

FOREIGN CRUDE LINES

Assam Oil Company	20	8	Brahmaputra Valley field to Digboi, Northeast India	Planned
Atlas Corporation	400	16	Fields in Neuquen territory to Bahia Blanda, Argentina	Proposed
Bombay Port Trust	50	8 to 24	Bombay, India, to serve Standard Vacuum Oil Co.	Merritt, Chapman and Scott Corp.
Direccion General de Yacimientos Petroliferos Fiscales	409		Plaza Huincul to Bahia Blanca, Argentina.	Under way
Egyptian Government	84	—	Suez-Cairo crude line.	Underway
Iraq Petroleum Company	—	20	Line diversion from Kirkuk-Haifa line to Lebanese coast terminal.	Planned
Petroelos Mexicanos	145	12	18 de Marzo field via Raynosa to Monterrey.	Considered
Petroleos Mexicanos	72	12	Poza Rica to Atzacapotzalco, Mexico.	Proposed
Petroleos Mexicanos	125	10	Jose Colomo to El Plan, Mexico.	Under way
Saskatoon Pipe Line, Limited	56	6	Milden to Saskatoon, Saskathewan, Canada.	Planned
Texas Petroleum Co.	60	4-6	Pta. Nio to La Dorada.	Under way
Texas Company	120	12	Porte Nino to Galan, Colombia, South America	Panama-Williams & Foster Wheeler
Yacimientos Petroliferos Fiscales Bolivianos	170	4	Bermejo to Tupisa, Bolivia.	Planned

FOREIGN PRODUCT LINES

Empresa Nacional del Petroleo	80	6⅝	Concon to Santiago, Chile.	Planned
Empresa de Petroleos	60	8	Contimplaca to Berrancabeneja, Colombia, South America	Anderson Bros. de Colombia
Governments of Southern Rhodesia and Portuguese E. Africa	200		Beria, Portuguese Mozamque to Umtalia, Southern Rhodesia.	Considered
North Atlantic Treaty Organization (NATO)	1920	4-10	To serve military bases in Western Europe.	Foster Wheeler
Petroleos Mexicanos	124	6	Lagos to Guadalajara, Mex.	Planned
Petroleos Mexicanos	54	6	Lagos to Aguascalientes, Mexico.	Planned
Petroleos Mexicanos	82	8	Salamanca to Lagos, Mex.	Planned

FOREIGN GAS LINES

Azienda Generale Italiana Petroli	90	12	Cortemaggiore to Bologna, Italy.	SNAM crews
Azienda Generale Italiana Petroli	120	16	Oremona Porto Mar to Ghera, Italy.	Montubi, Contractor
Azienda Generale Italiana Petroli	40	12	Rapalta-Bergamo, Italy.	
Dirrecion General del Gas del Estado	310	8	Plaza Huincul to Neuquen, Argentina.	
Empresa Macional del Petroleo	80	10	Concon to Santiago, Chile.	Planned
Petroleos Mexicanos	205	16	Monterrey to Torreon, Mex.	Under way
Petroleos Mexicanos	440	20	Brazil to Tampico to Poza Rica, Mexico.	Planned
Sui Gas Transmission Company, Karachi, Pakistan	350	16	Sui gas field to Karachi, Pakistan.	River Construction Company

pipe line personals

Charles S. Coates, senior vice president of Tennessee Gas Transmission Company, has been appointed executive vice president and general manager of Trans Canada Pipe Lines, Ltd., where he will direct the construction and operation of the 2200-mile Canadian natural gas line.

J. R. Donnell

O. F. Moore

John R. Donnell, assistant manager of Ohio Oil Company's supply and transportation department, has been elected a vice president and director and appointed manager of the department. He succeeds **O. F. Moore** who has retired. Moore advanced from stenographer to director and vice president in 45 years of service.

William F. Knode, Calgary, has been appointed general manager of the Alberta Gas Trunk Line Company, Ltd. Knode, a native of West Virginia, has been in Alberta since 1938. He was chief petroleum engineer with the Texas Railroad Commission during its organization and early stages of operation.

Mel Maddox, formerly with Pittsburgh Coke and Chemical Company, and Reilly Tar and Chemical Corporation, has joined Perrault Equipment, Tulsa, as salesman of pipe line equipment and supplies.

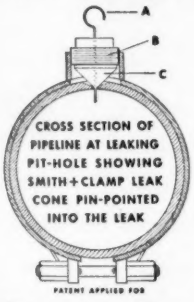
W. W. Shaw and **L. P. Humann** have been appointed assistant superintendents of Sinclair Pipe Line Company's right-of-way department. Both men will headquarter at the company's main office at Independence, Kansas.

Russell J. Judah has been named compressor department division engineer for Transcontinental Gas Pipe Line Corporation at Atlanta, Georgia. He was formerly junior engineer at Houston, Texas, in the company's compressor department.

Bettye M. Bohanon has been elected treasurer and assistant secretary of the Minnesota Pipe Line Company. Miss Bohanon has been associated with the petroleum industry for almost 25 years.

David E. Day, vice president of Richfield Oil Corporation, has been elected a director of Trans Mountain Oil Pipe Line Company, replacing **S. D. Bechtel,** who has resigned. Day has been a member of the Trans Mountain construction committee for the past two years.

Smith+Clamp Permits Plugging and Welding Pit-Hole Leaks in a Pipeline While Pumping Through It.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PATENT APPLIED FOR

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P. T. THIBODAUX, *Vice-President*
J. S. BURDEN, *Vice-President*

General Pipe Line Construction

Personals

Hall C. Hagler, maintenance foreman for Pan American Pipe Line Company at Snyder, Texas, has been transferred to Pan Am's Hulldale district near Eldorado (Schleicher County), Texas, as district foreman. **H. W. Hunt,** maintenance foreman in the Hulldale district, has been reclassified to district foreman and transferred to the Reinecke district (Borden County). **O. O. Merriman,** district foreman, has been transferred from the Reinecke district to the Quitman district (Wood County) Texas.

Milo S. Wharry has been promoted to district foreman in the Snyder area. Wharry has been serving with Pan Am as chief station engineer at Sabine Station near Longview, Texas. **L. F. Womack,** chief station engineer at Quitman, Texas, has been transferred to Sabine Station. Womack will supervise Quitman, Hawkins, and Sabine stations in his new assignment. **R. W. McGaw,** junior engineer at northern division headquarters near Longview, Texas, has taken a military leave of absence and has reported for active military service.

David F. Grozier, formerly publicity supervisor of Brooklyn Union Gas Company, has joined the public information bureau of the American Gas Association. Grozier replaces **Sidney Feldman,** who resigned July 1.

A. P. Craig has been named vice president in charge of sales for Trans Canada Pipe Lines with headquarters in Toronto, Canada. He was formerly vice president of Canadian Westinghouse.

P. N. Templeton

J. J. Harris

Paul N. Templeton has been named supervisor of tariffs and oil movements and will head a newly established oil movements department for Magnolia Pipe Line Company. Under his supervision will be **R. L. Council,** chief dispatcher, and **J. J. Harris,** who has been named coordinator of oil movements.

R. L. Hamilton

H. T. Chilton, Jr.

Ray L. Hamilton has been elected vice president of Bechtel Corporation. A pipe line engineer and widely recognized authority on pipe line design and construction, he has been with Bechtel 14 years.

H. T. Chilton, Jr., executive assistant to the vice president of operations, Service Pipe Line Company, is on special assignment to the Joint Construction Agency of the U. S. European Command to render technical and engineering counsel on products lines under construction in Europe by the U. S. Government. He relieves **C. B. Lester,** chief engineer of Mid-Valley Pipe Line Company, now on the same special assignment.

J. T. Dickerson

T. E. Swigart

Joe T. Dickerson has been named president of Shell Pipe Line Corporation. He has been vice president in charge of Shell Oil Company's Midland, Texas, exploration and production area. He is a graduate of the University of Oklahoma law school.

T. E. Swigart, president of Shell Pipe Line Corporation, has retired after 30 years of service, including 22 years as an officer of one or another of the Shell Companies.

Tom Warden, veteran right-of-way and claim agent for Lone Star Gas Company, has retired after 37 years service, 27 of them as company right-of-way man.

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over the years has eliminated all weak links on the HARLEY Units powered with

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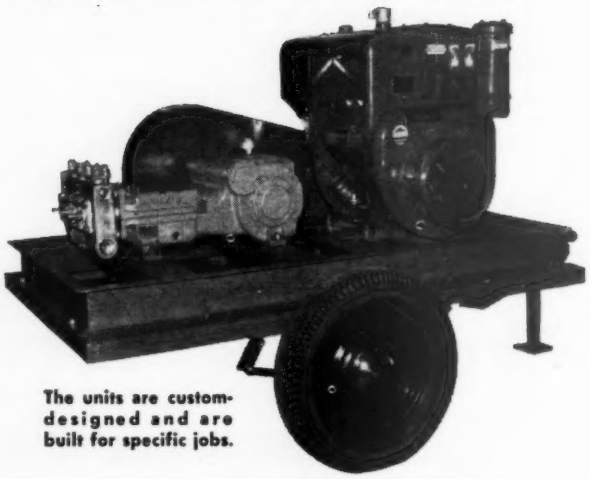

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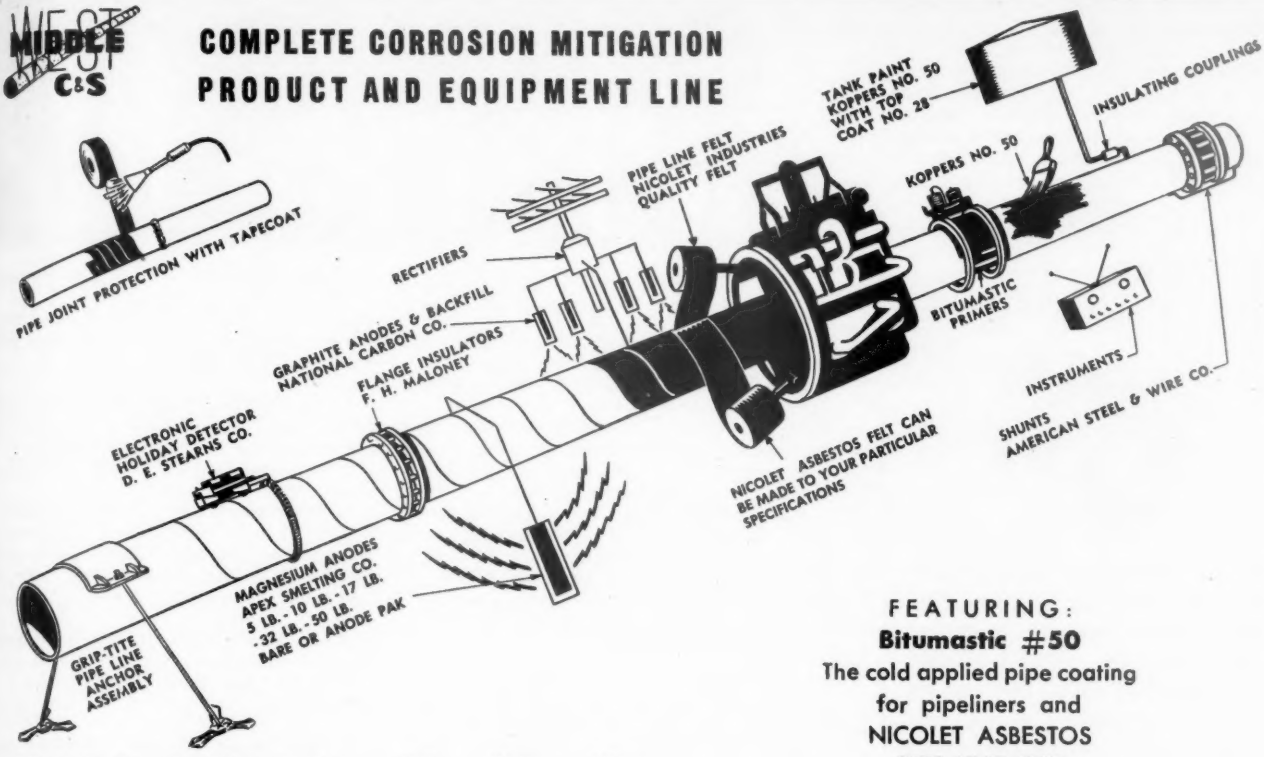
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NICOLET ASBESTOS FELT CAN BE MADE TO YOUR PARTICULAR SPECIFICATIONS

FEATURING:
Bitumastic #50
The cold applied pipe coating
for pipeliners and
NICOLET ASBESTOS
PIPE LINE FELT

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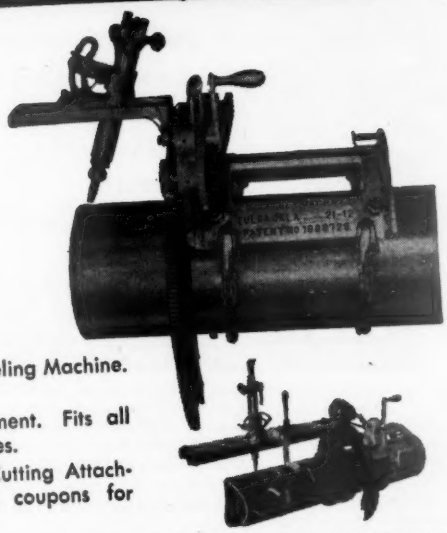
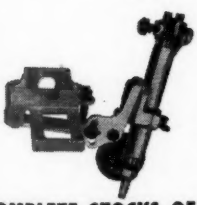
PIPE CUTTING AND BEVELING MACHINES

- **QUICKEST IN OPERATION**
  - Just slips over pipe
  - No hinges or latches to open or close
- **LIGHTEST WEIGHT**
- **FIVE MODELS** (for pipe from 4" to 36 inches)
- **ECONOMICAL**
- **FOR RENTAL OR PURCHASE**





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

Phone 3-3623 and 54-5141

C. A. MATHEY MACHINE WORKS, INC.
212 SOUTH FRANKFORT • TULSA, OKLAHOMA

Personals

Edward C. Mishou has been named general manager of the Minnesota Pipe Line Company, with offices at St. Paul, Minnesota. He was formerly associated with Interstate Oil Pipe Line Company as assistant to the division manager, southern division, Shreveport, Louisiana. Prior to his association with Interstate, he was with Ajax Pipe Line Company.

Hill Sanders

J. E. Ford

Charles Pinkner

J. N. Fuquay

Hill Sanders, vice president and general manager of Sun Pipe Line Company's crude lines department, has resigned to become president of Mid-Valley Pipe Line Company with offices in Longview, Texas. Succeeding Sanders in his former position is **James E. Ford,** formerly vice president and general manager of Sun Pipe Line's product lines department.

Charles Pinkner of Corpus Christi, former Sun southwest area superintendent, succeeds Ford as division superintendent of the products lines department. Succeeding Pinkner is **James Neill Fuquay,** formerly assistant superintendent of Sun's crude lines department.

L. L. Dyer, Lone Star Gas Company comptroller, has retired after 35 years service in the company's accounting operations and active participation in gas industry groups.

Colonel Phillip I. Baker, structural engineer, who recently retired from Army service, has joined Carroll E. Bradberry and Associates, Los Altos, California, consulting engineers. Company recently completed engineering of pipe line and terminal facilities in the Kuwait-Saudi Arabia neutral zone for American Independent Oil Company.

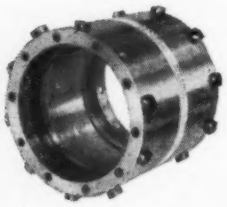
E. F. Morrill, former Mid-Valley president, has resigned that position to become head of the new petrochemical division of Standard Oil Company of Ohio.

J. Thurman Green, former director of safety for Sun Oil Company's production department, has been named safety director for Sun Pipe Line's crude lines department at Beaumont, Texas.

W. K. Smith has been appointed assistant division superintendent of the Martinsville division of Ohio Oil's Pipe Line Department.

N. B. Mavris, formerly assistant chief engineer of Continental Pipe Line Company, Ponca City, Oklahoma, has been promoted to the newly-created position of superintendent of the new Yellowstone Pipe Line Company. Headquarters of the company are at Spokane, Washington. Mavris, a graduate of Oklahoma A and M College, joined Conoco in 1951.

Weld+Ends Permits Welding a Pipeline While Pumping Through It.



A pipeline safety welding coupling for crude oil, gas, gasoline, asphalt, steam, chemical process and other pipelines. WELD+ENDS joins pipe securely so flow can be resumed immediately at full pressure. Welding can be performed while pipeline is in use days or weeks later. Sizes 2" to 30".

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5700 Detroit Avenue Cleveland 2, Ohio

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of
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★ Anode Resistance
★ Circuit Resistance
★ Polarization Effects
★ Current Density
with

VIBROGROUND
MODEL 263

DEPENDABLE ground resistance measurement, with a one-man push-button-operated instrument! No cranking, leveling or "babying" in the field with Vibroground Model 263—And look at all these added advantages:

LIGHT—less than 10 pounds "on-the-job" weight.

PORTABLE — Not only light, but small—only 9" x 6" x 6½"!

POWER — Self-contained standard No. 2 flashlight batteries — good for months of continuous use before replacing.

RANGES—0-1, 0-10, 0-100, 0-1,000 ohms all set . . . fast . . . on single selector.

ACCURATE to less than 3% on any range.

RUGGED for years of trouble-free field service.

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HORIZONTAL AND VERTICAL DISPLACEMENT[1] OF CROOKED HOLES, FT.

Measured depth, ft	Deviation, degrees from vertical																					
	1		2		3		4		5		6		7		8		9		10		11		12	
	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V
500	9	.1	17	3	26	.7	35	1.2	44	1.9	52	2.7	61	3.7	70	4.9	78	6.2	87	7.6	95	9	104	11
750	13	.1	26	.5	39	1.0	52	1.8	65	2.9	78	4.1	91	5.6	104	7.3	117	9.2	130	11	143	14	156	16
1,000	17	.2	35	.6	52	1.4	70	2.4	87	3.8	105	5.5	122	7.4	139	9.7	156	12	174	15	191	18	208	22
1,200	21	.2	42	7	63	1.6	84	2.9	105	4.6	125	6.6	146	8.9	167	12	188	15	208	18	229	22	249	26
1,400	24	.2	49	8	73	1.9	98	3.4	122	5.3	146	7.7	171	10	195	14	219	17	243	21	267	26	291	31
1,600	28	.2	56	1.0	84	2.2	112	3.9	139	6.1	167	8.8	195	12	223	16	250	20	278	24	305	29	333	35
1,800	31	.3	63	1.1	94	2 5	126	4.4	157	6.9	188	9.9	219	13	251	18	282	22	313	27	343	33	374	39
2,000	35	3	70	1.2	105	2.7	140	4.9	174	7.6	209	11	244	15	278	19	313	25	347	30	382	37	416	44
2,200	38	.3	77	1.3	115	3.0	153	5.4	192	8.4	230	12	268	16	306	21	344	27	382	33	420	40	457	48
2,400	42	.4	84	1.5	126	3.3	167	5.9	209	9.1	251	13	292	18	334	23	375	30	417	36	458	44	499	52
2,600	45	4	91	1.6	136	3.6	181	6.3	227	9.9	272	14	317	19	362	25	407	32	451	39	496	48	541	57
2,800	49	.4	98	1.7	147	3.8	195	6.8	244	11	293	15	341	21	390	27	438	34	486	43	534	51	582	61
3,000	52	.4	105	1.8	157	4.1	209	7.3	261	11	314	16	366	22	418	29	469	37	521	46	572	55	624	66
3,200	56	.5	112	2.0	167	4 4	223	7.8	279	12	334	18	390	24	445	31	501	39	556	49	611	59	665	70
3,400	59	.5	119	2.1	178	4.7	237	8.3	296	13	355	19	414	25	473	33	532	42	590	52	649	62	707	74
3,600	63	.5	126	2 2	188	4.9	251	8.8	314	14	376	20	439	27	501	35	563	44	625	55	687	66	748	79
3,800	66	.6	133	2.3	199	5.2	265	9.3	331	14	397	21	463	28	529	37	594	47	660	58	725	70	790	83
4,000	70	6	140	2.4	209	5.5	279	9.8	349	15	418	22	487	30	557	39	626	49	695	61	763	73	832	87
4,200	73	.6	147	2.6	220	5.8	293	10	366	16	439	23	512	31	585	41	657	52	729	64	801	77	873	92
4,400	77	.7	154	2.7	230	6.0	307	11	384	17	460	24	536	33	612	43	688	54	764	67	840	81	915	96
4,600	80	.7	161	2.8	241	6.3	321	11	401	18	481	25	561	34	640	45	720	57	799	70	878	85	956	101
4,800	84	.7	168	2.9	251	6.6	335	12	418	18	502	26	585	36	668	47	751	59	834	73	916	88	998	105
5,000	87	.8	175	3.0	262	6.9	349	12	436	19	523	27	609	37	696	49	782	62	868	76	954	92	1,040	109
5,200	91	.8	181	3.2	272	7.1	363	13	453	20	544	28	634	39	724	51	813	64	903	79	992	96	1,081	114
5,400	94	.8	188	3.3	283	7.4	377	13	471	21	564	30	658	40	752	53	845	66	938	82	1,030	99	1,123	118
5,600	98	.8	195	3.4	293	7.7	391	14	488	21	585	31	682	42	779	54	876	69	972	85	1,069	103	1,164	122
5,800	101	9	202	3.5	304	8.0	405	14	506	22	606	32	707	43	807	56	907	71	1,007	88	1,107	107	1,206	127
6,000	105	9	209	3.7	314	8.2	419	15	523	23	627	33	731	45	835	58	939	74	1,042	91	1,145	110	1,247	131
6,500	113	1.0	227	4.0	340	8.9	453	16	567	25	679	36	792	48	905	63	1,017	80	1,129	99	1,240	119	1,351	142
7,000	122	1.1	244	4.3	366	9.6	488	17	610	27	732	38	853	52	974	68	1,095	86	1,216	106	1,336	129	1,455	153
7,500	131	1.1	262	4.6	393	10	523	18	654	29	784	41	914	56	1,044	73	1,173	92	1,302	114	1,431	138	1,559	164
8,000	140	1.2	279	4.9	419	11	558	20	697	30	836	44	975	60	1,113	78	1,251	98	1,389	122	1,526	147	1,663	175
8,500	148	1.3	297	5.2	445	12	593	21	741	32	889	47	1,036	63	1,183	83	1,330	105	1,476	129	1,622	156	1,767	186
9,000	157	1.4	314	5.5	471	12	628	22	784	34	941	49	1,097	67	1,253	88	1,408	111	1,563	137	1,717	165	1,871	197
9,500	166	1.4	332	5.8	497	13	663	23	828	36	993	52	1,158	71	1,322	92	1,486	117	1,650	144	1,813	175	1,975	208
10,000	175	1.5	349	6.1	523	14	698	24	872	38	1,045	55	1,219	74	1,392	97	1,564	123	1,736	152	1,908	184	2,079	218
10,500	183	1.6	366	6.4	550	14	732	26	915	40	1,098	58	1,280	78	1,461	102	1,643	129	1,823	160	2,004	193	2,183	229
11,000	192	1.6	384	6.7	576	15	767	27	959	42	1,150	60	1,341	82	1,531	107	1,721	135	1,910	167	2,099	202	2,287	240
11,500	201	1 7	401	7.0	602	16	802	28	1,002	44	1,202	63	1,402	86	1,600	112	1,799	142	1,997	175	2,194	211	2,391	251
12,000	209	1.8	419	7.3	628	16	837	29	1,046	46	1,254	66	1,462	89	1,670	117	1,877	148	2,084	182	2,290	220	2,495	262
12,500	218	1.9	436	7.6	654	17	872	30	1,090	48	1,307	68	1,523	93	1,740	122	1,955	154	2,171	190	2,385	230	2,599	273

[1]Assuming uniform deviation all in one direction. The figures for horizontal displacement are therefore a maximum limit.

Horizontal and vertical displacement for intermediate depths or horizontal displacement for intermediate angles may be determined by interpolation. Vertical displacement for angles not included in the table may be determined by multiplying the measured depth by 1 minus the cosine of the angle. $V = D(1 - \cos\theta)$. The vertical depth of crooked holes is always less than the measured depth.

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IN ENGLAND	PROCON (GREAT BRITAIN) LIMITED 112 STRAND, LONDON, W. C. 2

PROCON ®

To obtain more information on products advertised see page E-57

GASO PUMP PERFORMS *TRIPLE SERVICE* IN 60,000 BARREL UNDERGROUND STORAGE PLANT

ANCHOR PETROLEUM'S UNDERGROUND STORAGE PLANT near Bath, N. Y. The pumping unit consists of a Fig. 1742 2½" x 5½" x 10" Gaso Duplex Piston Power Pump driven by Model 145-GKU Waukesha Power Unit, complete with steel skids, V-Belt Drive and Guard. Capacity from 38 GPM to 330 GPM at pressures from 1400 to 500 pounds.

The flexibility of Gaso Pumping Units is dramatically demonstrated in the installation pictured above, one of several operated by Anchor Petroleum Company:

1. In less than 90 days, operating in winter weather, the Gaso Pump washed out salt formation to give Anchor a 60,000-barrel underground storage reservoir.
2. Since then the pump has been storing gas in the cavity at a rate of 300 GPM.
3. The same pump will be used to displace the gas for consumers' use. Interchangeability of liners assures maximum efficiency on all jobs.

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GASO PUMPS

for every oil industry need

WEIGHT[1] OF FLUID ON PLUNGER IN PUMPING WELLS, LB. PER 100 FT.

Plunger diameter, in.	Rod diameter, in.	Wt. of rods, lb. per 100 ft.	Average gravity of liquid, deg. A.P.I.									
			16	20	24	28	32	36	40	44	48	52
1	5/8	110	20	19	19	18	18	17	17	17	16	16
	3/4	162	14	14	14	13	13	13	12	12	12	11
1 1/16	5/8	110	24	23	23	22	22	21	21	20	20	19
	3/4	162	18	18	18	17	17	16	16	16	15	15
1 1/4	5/8	110	38	37	36	35	34	34	33	32	31	31
	3/4	162	33	32	31	30	29	29	28	27	27	26
1 1/2	5/8	110	61	59	58	56	55	53	52	51	50	49
	3/4	162	55	54	52	51	50	48	47	46	45	44
	7/8	235	48	47	46	45	44	43	42	41	40	39
	1	295	41	40	39	38	37	36	35	34	34	33
1 3/4	5/8	110	87	85	83	81	79	77	75	73	72	70
	3/4	162	82	79	77	75	74	72	70	69	67	66
	7/8	235	75	73	71	69	68	66	64	63	62	60
	1	295	67	66	64	62	61	59	58	57	55	54
1.7810	5/8	110	91	88	86	84	82	80	78	76	75	73
	3/4	162	85	83	81	79	77	75	73	72	70	68
	7/8	235	79	76	74	73	71	69	68	66	65	63
	1	295	71	69	67	66	64	62	61	60	58	57
2	5/8	110	118	115	112	109	106	104	101	99	97	95
	3/4	162	112	109	106	104	101	99	96	94	92	90
	7/8	235	106	103	100	98	95	93	91	89	87	85
	1	295	98	95	93	91	88	86	84	82	80	79
2 1/4	5/8	110	152	148	145	141	138	134	131	128	125	123
	3/4	162	147	143	139	136	132	129	126	123	121	118
	7/8	235	140	137	133	130	126	123	121	118	115	113
	1	295	133	129	126	123	120	117	114	111	109	107
2 1/2	5/8	110	191	186	181	177	172	168	164	161	157	154
	3/4	162	186	181	176	172	167	163	160	156	153	149
	7/8	235	179	174	170	165	161	158	154	150	147	144
	1	295	171	167	163	158	155	151	147	144	141	138
2 3/4	5/8	110	234	228	222	216	211	206	201	197	192	188
	3/4	162	228	222	217	211	206	201	196	192	188	184
	7/8	235	222	216	210	205	200	195	191	186	182	178
	1	295	214	208	203	198	193	189	184	180	176	172
3	3/4	162	275	268	261	255	248	242	237	231	226	221
	7/8	235	269	262	255	248	242	237	231	226	221	216
	1	295	261	254	248	241	236	230	225	219	215	210
3 1/4	3/4	162	326	318	310	302	294	287	281	274	268	262
	7/8	235	320	311	303	296	288	282	275	269	263	257
	1	295	312	304	296	289	281	275	268	262	256	251
3 3/4	3/4	162	441	429	418	407	397	388	379	370	362	354
	7/8	235	434	422	412	401	391	382	373	365	357	349
	1	295	426	415	404	394	385	375	367	358	350	343
4 1/4	3/4	162	571	556	542	528	515	503	491	480	469	459
	7/8	235	564	550	535	522	509	497	485	474	464	454
	1	295	557	542	528	515	502	490	479	468	458	448
4 3/4	3/4	162	718	699	681	664	648	632	617	603	590	577
	7/8	235	711	692	675	658	642	626	612	598	585	572
	1	295	704	685	667	651	635	620	605	591	578	566

[1]At 60 deg. fahrenheit. No allowance has been made for expansion of oil at the temperatures ordinarly encountered in wells. No allowance has been made for the lifting effect of any gas that may be present.

XUM

FIRST *to help put the future in East Texas oil production...*

Back in the early '30s, when the East Texas oil field was "wide open," the oil industry faced a major problem of price deflation. Through the guidance of the First National Bank in Dallas, proration problems were licked and prices were stabilized. Pioneering a new concept of financing for independent producers, the First provided a new method of making oil loans by helping to establish oil in the ground as a bankable commodity.

FIRST NATIONAL BANK in Dallas

Member Federal Deposit Insurance Corporation

put FIRST financing in your own oil future

OIL WOMEN. Above are some of the 600 members of the Association of Desk and Derrick Clubs of North America at the 1954 annual convention at Banff Springs Hotel, Canada. Seated are 1954 officers and directors; Elinore McAdam (on chair arm), Coastal Oil Company, Newark; Dorothy Kassel, Kobe, Inc., Fort Worth, Texas; Lorene Porter, Harold D. Herndon, San Antonio, Texas, treasurer; Elouise Norris, Dooley Engineering Company, Oklahoma City; Sybil Sureck, Union Oil Company of Oklahoma, Oklahoma City, second vice president and 1955 president. Meitzie Palmer, Ohio Oil Company, Los Angeles, first vice president; Irene Stimson Cox, Panhandle Producing Company, San Antonio, president; Margaret Neff, Dixie Geological Service, Jackson, Mississippi, former president; Betty Heaton, American-Leduc Petroleum, Edmonton, Canada; Bea Freyou, Esso Standard Oil Company, New Orleans; Angela Cross, Plymouth Oil Company, Pittsburgh, treasurer; Minetta Miller, Ernest S. Baker, Denver, and Lydia Babka, Honolulu Oil Corporation, San Francisco.

OFFICERS AND REGIONAL DIRECTORS elected at the convention were: Leta Dillon, Tulsa, director, Region 6; Doris Rooney, Calgary, Region 7; Minetta Miller, Denver, second vice president; Bettie Conley, New Orleans, Region 3; Irma Cline, Wichita Falls, Region 5; Sybil Sureck, Oklahoma City, president-elect; Irene Stimson Cox, president for this year; Eloise Limbocker, Beaumont, Region 4; Edna Hurry, New York, first vice president; Frankie Frensley, Dallas, treasurer; Pauline Colahan, Bakersfield, California, Region 8, and Nelle Barclay, Oklahoma City, secretary. Not shown, Angela Cross, Pittsburgh, Pennsylvania, Region 1, and Catherine A. Connell, Chicago, Illinois, director of Region 2.

TWO PRESIDENTS, Irene Stimson Cox, president of the D&D Clubs, and Frank Porter, president of API. President Porter gave an inspiring address on "A Pattern for the Future."

DISTRIBUTION CENTER. These committee members won the honor of having Desk and Derrick's first association office located in Tulsa, Oklahoma; Leta Dillon, past president of Tulsa club, and one who sparked the campaign; Maxine Hacke, 1954 Tulsa D&D president; Lucille Fulk; Hazel Kirk; Olive Kasishke; Faye Reid; Jane Hilderbrand; Helen Egan; Kathleen Ryan.

DESK & DERRICK CONVENTION PICTORIAL

TOP FLIGHT PHOTOGRAPHER GROUP for the D&D convention were: Steve Miranda, Dresser Industries (center with Scotch cap), Hal Coops, California photographer (striped tie), Ruth Burris, left, and Verlin Stoner, second from right. Two Dresser Industries employees are Beatrice Kilcoin, second from left, and Agnes Barnes, right.

PREMIER SPEAKS. Betty Heaton, regional director, of Edmonton, below, introduced Premier E. H. Manning, who was speaker at the impressive banquet given by the Province of Alberta to the D&D convention.

BULLETIN AWARDS. Prizes and certificates were awarded winners of D&D bulletins at luncheon. At speakers' table were: Ernestine Adams, chairman, Bulletin Contest and managing editor of THE PETROLEUM ENGINEER; Irene Stimson Cox; Joan Scarrott, president, Calgary Club, presiding; Lee Wilson Hoover, first president of the Association; Meitzie A. Palmer, first vice president; Edna Resky, Calgary, convention chairman, and Margaret Neff, immediate past president of the Association.

Service, Jackson, Mississippi, former president; Betty Heaton, American-Leduc Petroleum, Edmonton, Canada; Bea Freyou, Esso Standard Oil Company, New Orleans; Angela Cross, Plymouth Oil Company, Pittsburgh, treasurer; Minetta Miller, Ernest S. Baker, Denver, and Lydia Babka, Honolulu Oil Corporation, San Francisco.

Worth, Texas; Lorene Porter, Harold D. Herndon, San Antonio, Texas, treasurer; Elouise Norris, Dooley Engineering Company, Oklahoma City; Sybil Sureck, Union Oil Company of Oklahoma, Oklahoma City, second

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Harry L. Dedman, H. F. Poyner, and Frank E. McGonagill, Jr., petroleum engineers in the oil and gas department, study potential oil loans with Harold Vance, right, department manager.

Bank Loans on Oil and Gas Production

Engineer's and geologist's figures can determine security for loan on producing property more accurately than that behind most conventional bank loans

HAROLD VANCE

BANK loans to oil operators were practically unknown prior to about 1930. Before that time the production and prices of crude varied widely making the income from oil production so erratic that bankers hesitated loaning depositors' money to develop more oil production.

During the early East Texas days, from 1931 to about 1934, such financing called for oil payments which would return to the lender $3 for each $1 advanced to drill a well in known producing territory. This type of loan was still not understandable to the average banker, who viewed such financing with much uncertainty.

Stabilization of prices and production rates brought about by proration made loans to oil producers more acceptable. A knowledge of how long an oil property would produce was still a mystery to bankers until they learned that petroleum engineers and geologists could determine the amount of recoverable oil with engineering accuracy. Using the engineer's or geologist's figures, the security could be determined even more accurately than the security behind the conventional bank loan.

Since the late 1930's bank loans to operators for the development and purchase of properties has become more common in oil-producing territory. Bankers in the large cities saw the advantage of oil loans and rapidly expanded their bank's loans in the heart of the oil country while the oil country banks looked on. Today the oil country banker, through his connections with larger banks having oil and gas departments, can and will be able to take care of the financial needs of his customers for the purchase and development of oil and gas properties.

The term oil or gas loan as used herein is a loan secured by a mortgage on a producing property having the ability to produce future net income from the production of oil and/or gas and using this income, in whole or in part, to pay off the loan — thus, the primary security is the expected income from the property. The secondary security is the net worth of the borrower who signs the note.

Loans on oil production differ from the ordinary real estate loans because the property held as security is sold in monthly installments and part of the proceeds from the sale is used to pay off the loan.

Many lending agencies are engaged in the oil loan business, and some lend money for interest and acquire at the same time an interest in the property. These concerns are really in business with the borrower and receive part of the profits plus interest on the money loaned. Banks receive no profit from the borrower's business, but do expect the return of the money loaned plus interest; therefore, banks must look much closer at the security offered.

Many oil and gas loans are made for the purpose of purchasing an interest in a producing property or for the purpose of paying for additional development on a presently owned interest, or both. In the first instance, the purchaser is normally expected to furnish part of the purchase price, with the balance supplied by the bank which expects repayment out of production to retire the loan in a reasonable length of time. The amount loaned by the bank will naturally depend on its policy. It may be possible to borrow from a bank the full purchase price of a piece of property, but deals like this are hard to find. The money supplied by the purchaser is usually called equity money and recently some companies have been formed to purchase properties and use all its funds as equity money, borrowing the balance.

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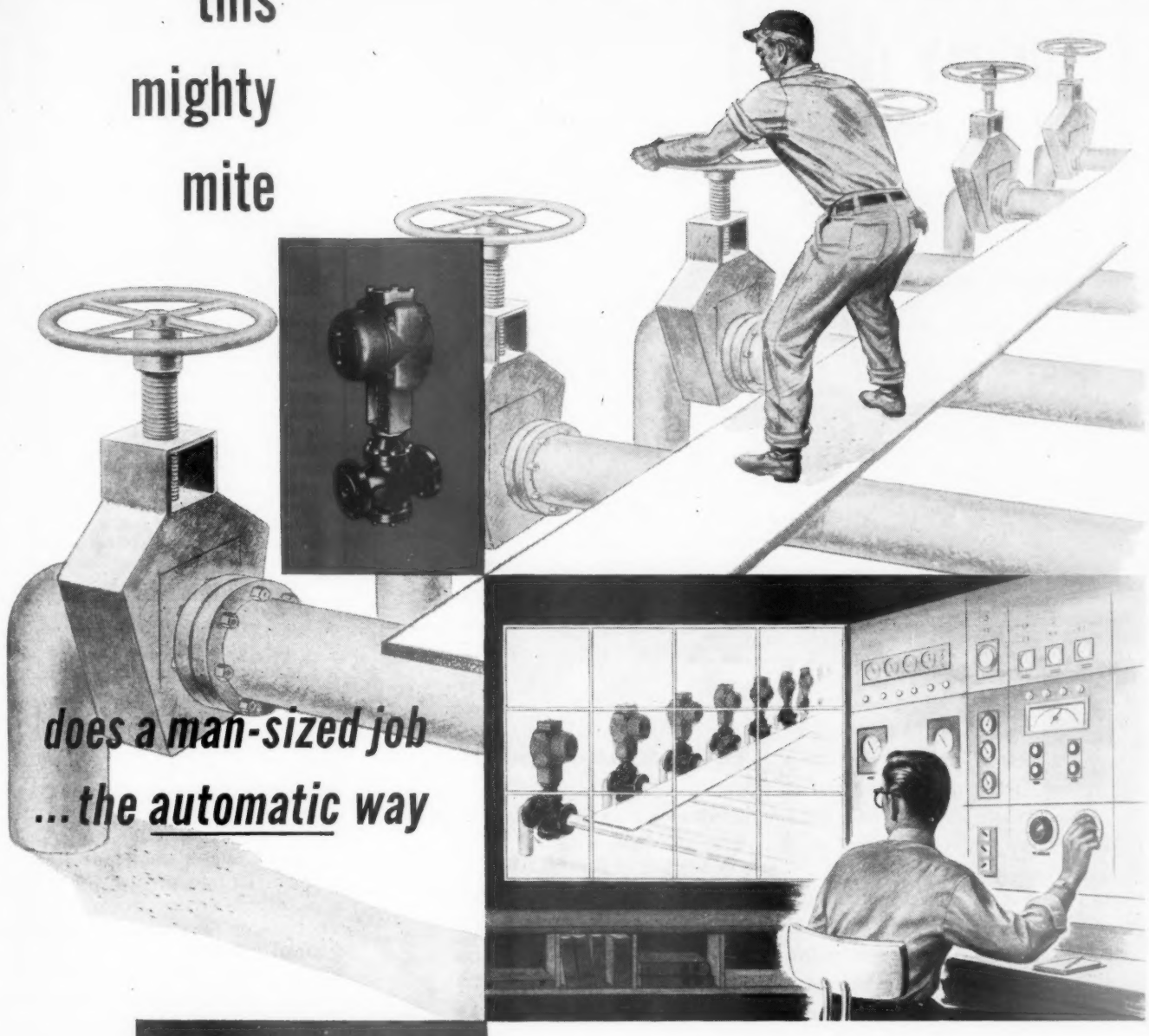

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The initial capacity of the line is 44,000 barrels of mixed products every day. The West Memphis terminal, will have a storage capacity of one million barrels, with railroad, motor transport and river barge-loading facilities. Other terminals at Fort Smith and Conway, Arkansas will be served by railroad and motor transport to supply distributors in the area. This is another example of SUNRAY's planned expansion program.

The Company is primarily engaged in producing crude oil and refining of petroleum products. It is not a marketing company, but because of special transportation and sales facilities such as the Oklahoma-Mississippi line it helps make available quality products to independent jobbers and dealers in many parts of the country.

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The Author

Harold Vance is vice president and manager of the Oil and Gas Department of The Second National Bank of Houston, Texas. He was head of the Petroleum Engineering Department for Texas A & M College for 18 years before he joined the bank in 1952. After graduating from the University of Southern California with a B.S. degree in petroleum engineering, Vance spent three years with the United Oil Company of Los Angeles, California and with the United States Bureau of Mines in Casper, Wyoming. He was division petroleum engineer and division superintendent with Marland Oil Company and its successor, Continental Oil Company from 1926 to 1929. Vance was a consulting engineer and independent oil operator in conjunction with his duties at Texas A and M College.

The Borrower

In the usual transaction, the land owner conveys to another person an oil and gas lease, which in Texas is a conveyance of, usually, 7/8 of the oil and gas. The grantor in this case is known as the lessor, and grantee is the lessee. The lessee, or owner of the oil and gas lease, is charged with the development and operation costs of the property and the lessor retains unto himself 1/8 of all the oil and gas produced, free of all costs, except production and ad valorem taxes on his retained interest. This retained interest is called royalty but is more properly known as landowner's royalty. The lessor and lessee usually have the right to sell part or all of their interest and often do divest themselves of part of it. The oil and/or gas produced from the property is generally sold to a disinterested purchaser who makes payment direct to the various owners.

The lessee may create out of his interest an overriding royalty or production payment. The overriding royalty is part of the lessee's interest free of all cost of operation for the life of the lease, whereas the production payment is a similar interest limited to a specified amount of money or barrels of oil or cubic feet of gas.

The loan may be made to a lessee who is the operator of the property or to a non-operating lessee owner. In this latter case there is an operating lessee interest owner who is operating the property for the benefit of his own interest as well as those who also own a part of the leasehold interest, and the ability of this person as an operator is taken into consideration.

The loan may be made to a royalty

owner, an overriding royalty owner, or the owner of a production payment. The owner of these interests ordinarily receive their payments for oil and/or gas runs direct from the purchaser. The owners of these interests have nothing to do with the operator of the property.

Production Payments

Production payments are used for various purposes in the oil industry. A lessor may reserve an oil payment of a certain amount of money per acre as part of the purchase price for its lease. An operator may sell a production payment to create income for the purpose of offsetting drilling intangibles, and oil payments are used in the purchase of royalty or working interests in producing properties.

The Production Payment Method of Purchasing Oil and Gas Properties. Banks are often called upon to finance production payments used in connection with the purchase of producing properties. In such a transaction, the owner of the working interest sells it subject to a reserved production payment for a certain total amount in dollars plus interest. Normally, the oil payment is payable out of a large percentage of the working interest, with the remaining portion of the working interest being only enough to adequately cover the estimated operating expenses. The owner then sells the oil payment to a disinterested third party who, in turn, borrows the purchase price at a lesser interest rate. The differential in interest is the net income the purchaser of the oil payment receives.

Example:

A owns the 7/8 working interest in a producing oil property and has agreed to sell his interest to B for $140,000. A is to receive his money in two parts as follows:

A executes an assignment to B for the 7/8 interest subject to an oil payment of $100,000 plus 6 per cent interest payable out of 80 per cent of the 7/8. For this assignment B pays A $40,000.

Now A sells his retained production payment to C for $100,000. C borrows the $100,000 at 5 per cent interest from Bank D. The bank takes a mortgage and an assignment of the production payment.

Then, 20 per cent of the income from production is paid directly to B by the purchasing company and this income to B is sufficient to pay operating expenses only. Eighty per cent of the income goes to C, the owner of the production payment, until he has received $100,000 plus 6 per cent interest, then this 80 per cent interest goes to B.

Usually B will have no net income

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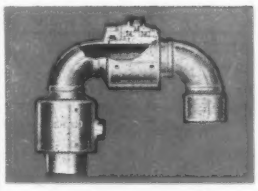

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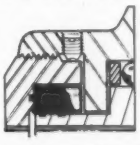

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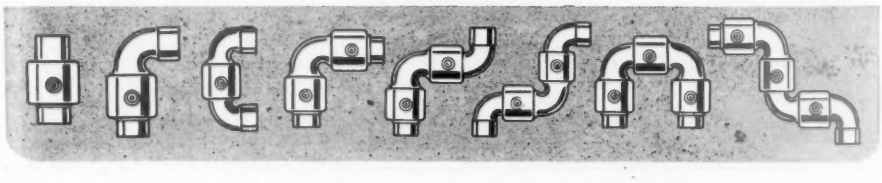

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until the production payment has been retired and C, who purchased the production payment, will have a net income equal to the difference in interest rates paid by the production payment and that charged by the bank — in this case one per cent.

Amount of Loan

Banks are loaning from 40-65 per cent of the present value of the future net income before income taxes from the property depending upon the present value discount factor and the bank policy. The term "present value" in this case means the present value of the future net income from the property discounted at a certain interest rate. The term "present value" as used herein may be better understood when one says, if the price of the property is equal to the present value figures, then the purchase price plus the selected interest will be returned over the life of the property.

In determining the present value of producing properties, the banks may not place any value on sands known to be productive but which are not producing at the time the valuation is made. The owner of the properties, naturally, considers the known productive sands back of the pipe as valuable as those being produced, and also gives some speculative value to prospective deeper sands; therefore, a bank's valuation for loan purposes is seldom a measure of the market value of the property and the borrower should not consider the valuation as an index of the market value of his property.

The present value of the property is then of utmost importance to the bank. The present value of the property is usually determined by a petroleum engineer or geologist acting in a consulting capacity or as a direct employee of the bank, or both. Table 1 is an illustration of the method of arriving at the present value of a property that reaches its economic limit in 8 years. The amount to be loaned in this case is ½ of the present value when a 5 per cent-value discount factor is used.

The gross income figures shown in Table 1 are arrived at by using an estimate of the amount of recoverable oil and/or gas and the rate at which it is recovered times an estimated future price. The methods of estimating future recoveries are well-known to engineers and geologists specializing in such work, and banks, as well as other lending agencies, are dependent upon qualified persons to prepare the estimates.

If the present value of the property is the yardstick used in determining the amount a bank will loan, then the percentage of the gross income from the property which will be applied to re-

ture the loan is of equal importance.

For example, in Table 1, it will be noted that the present value of the expected production from the property is twice the amount of the loan. This means that there is a factor of safety of 2 when the loan was initiated. If this same factor of safety is to be maintained throughout the payout period, at least 50 per cent of the gross income should be taken to retire the loan. Fig. 1 illustrates a loan starting with a safety factor of 2 and using 61 per cent of the runs to retire the loan. It will be noted that the factor of safety towards maturity of the loan increases very rapidly. At this time, the loan could be rearranged and additional funds advanced so that the renewed loan would also start with a factor of safety of 2. Actually, this is done in many cases.

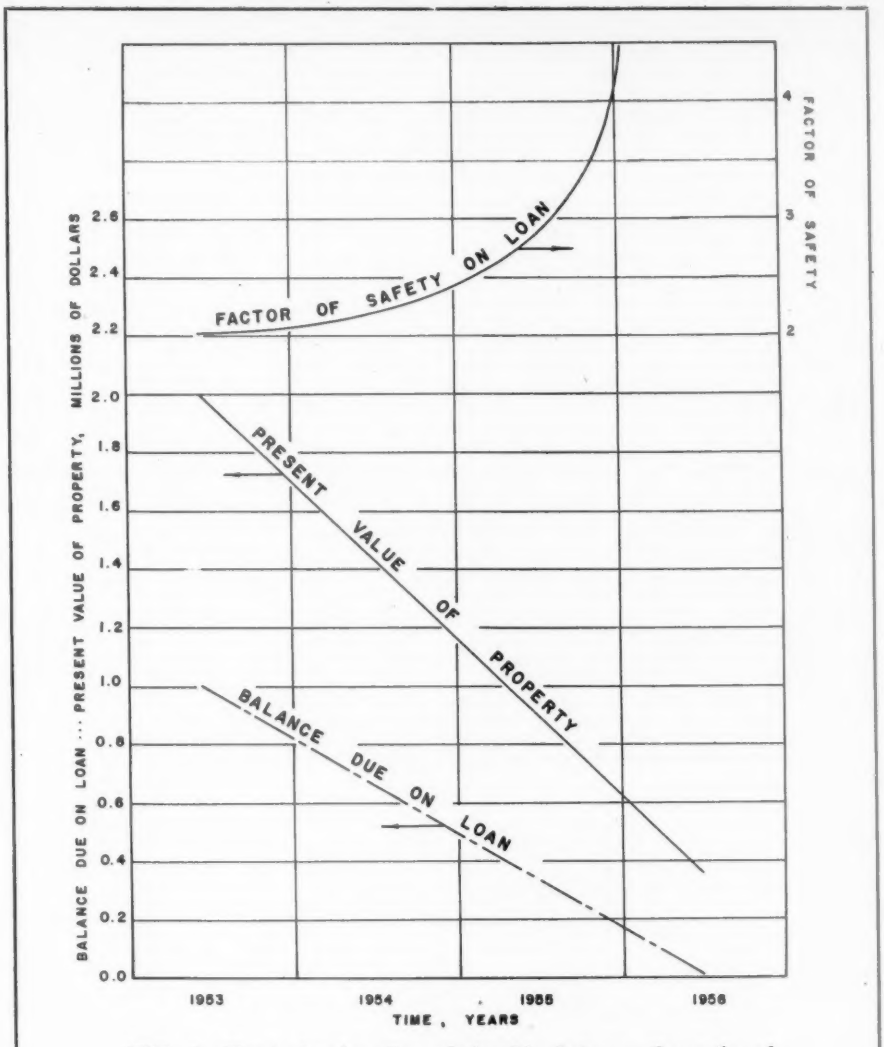

FIG. 1. Chart showing the relationship between the ratio of present value of property and balance due on loan (factor of safety on loan) when 61 per cent of the runs are used to pay off the principal.

Title to Property

If the bank is satisfied that the property under consideration is sufficient security for the loan requested and that the payments out of production will retire the loan in a reasonable length of time without jeopardizing the security, then the title to the property to be mortgaged must be proved to be in the borrower. Ordinarily loans are not made until the purchaser of the oil and gas produced is satisfied as to the ownership of the various interests. Therefore, the bank's attorney has the benefit of title examination made for the purchaser who does not expect to pay twice for the oil and/or gas he purchases. Often a title opinion by the purchaser's attorneys plus an examination of a supplemental abstract will satisfy the bank's attorney.

Mortgage

The mortgage usually contains a chattel mortgage on all personal property connected with the operation of the mineral interest, and the power to sell the property in case of default and use the money thus obtained to pay off the debt. It also contains an assignment of 100 per cent of the money from the sale of production credited to the interest mortgaged. The mortgage usually contains two "catchall clauses": the first takes under mortgage any other interest in the property the borrower might have in addition to that enumerated in the mortgage; and, the second secures any other debt now owing the lender or any money to be advanced to him in the future.

Table 1. Example of a present value method of evaluation

Lease year	Gross income	Est. future operating expense	Net income	Pres. value discount factor 5%	Present value
1st	$ 87,500.00	$ 5,000.00	$ 82,500.00	.9756	$ 80,487.00
2nd	$ 57,750.00	$ 5,000.00	$ 52,750.00	.9286	$ 48,983.65
3rd	$ 38,062.50	$ 5,000.00	$ 33,062.50	.8839	$ 29,223.94
4th	$ 26,250.00	$ 5,000.00	$ 21,250.00	.8413	$ 17,877.63
5th	$ 18,375.00	$ 5,000.00	$ 13,375.00	.8007	$ 10,709.36
6th	$ 13,125.00	$ 5,000.00	$ 8,125.00	.7621	$ 6,192.06
7th	$ 9,625.00	$ 5,000.00	$ 4,625.00	.7254	$ 3,354.98
8th	$ 7,217.50	$ 5,000.00	$ 2,217.50	.6905	$ 1,531.18
Total	$257,905.00	$40,000.00	$217,905.00		$198,359.80
Present value of expected production from the lease					$198,359.80
Amount of loan (½ of present value of $198,359.80)					$ 99,179.90

Payout on such a loan, taking 75 percent of the gross income plus interest would be about 24 months.

(Estimated gross income for the ninth year was found to be less than the yearly operating costs, therefore, the property had reached its economic limit at the end of eight years.)

The Indebtedness

The note evidencing the debt should be prepared with the future needs of the borrower in mind. If future advances are anticipated to take care of additional development, the "master note" may be used. The master note has a principal amount in excess of the money actually advanced at the time the loan is made. Therefore, this note has a reserve of unadvanced principal which the borrower, by agreement, may call for up to the full amount of the master note.

The total advances under the master note cannot exceed the face amount of the note. For example, if the face amount of the note is $100,000 and $80,000 has been advanced, then although the payments reduce the amount of the debt to $50,000, only $20,000 more could be advanced on the note. Interest is charged only on the amount of the unpaid balance from date of disbursement, and there is

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some final maturity date on the note when the entire amount of the loan is due and payable.

Ordinarily, the face amount of the master note does not mean that the borrower has at that time sufficient security to justify a loan equal to the face amount of the note, and the bank may consider loaning up to that amount if the security becomes available and general conditions warrant. The borrower should thoroughly understand the foregoing.

A careful check of the security and title is made before any additional funds are advanced.

Loan Agreement

A loan agreement is considered essential where the master note is used and may be prepared in recordable form, although the usual practice is not to place it on record. The loan agreement between the borrower and bank may place additional covenants and obligations on the borrower besides those already in the deed of trust and master note. In the case of small master notes, a letter agreement may suffice, setting out as minimum requirements, that the bank is under no obligation to make advances other than the original advance, but may do so at its own discretion, provided the security is considered ample, title requirements are satisfactory, and there has been no default in payments. Also, if the bank is willing to accept minimum payments less than those called for in the master note, the agreement may so provide.

As the deed of trust is usually an assignment of all runs, the loan agreement is the place to provide for how much of the money received from the runs is to be returned to the borrower. The earning ability of the property held under mortgage may be maintained only by returning to the borrower sufficient money out of runs to properly operate the property.

Information Needed

The following information will finally be needed to consummate an oil loan.

1. Name, address and telephone number of applicant.
2. Amount of loan and proposed monthly payments on loan.
3. Name and address of operator of properties.
4. Company purchasing oil or gas. Price of the oil and/or gas.
5. Name, location, and legal description of properties to secure loan.
6. Amount and type of interest in above leases.
7. Title information.
8. Production and income history including copies of last six months run statements.
9. The following information is needed by the engineers in order to prepare an independent appraisal of the properties, even though an appraisal report is submitted with the application.
   a. Map of area
   b. Electric logs of all wells in area
   c. Core analysis
   d. Completion interval and formation from which wells are producing
   e. Bottom hole pressure history
   f. Cost of production
10. Financial statement of applicant.

* * *

Old bankers never die, either. They just lose interest.

* * *

Engineering Student: Gee, he's dumber than me

Petrol. Prof.: Dumber than I.

Student: All right then, he's dumber than both of us.

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She did.

He left a widow, and three children.

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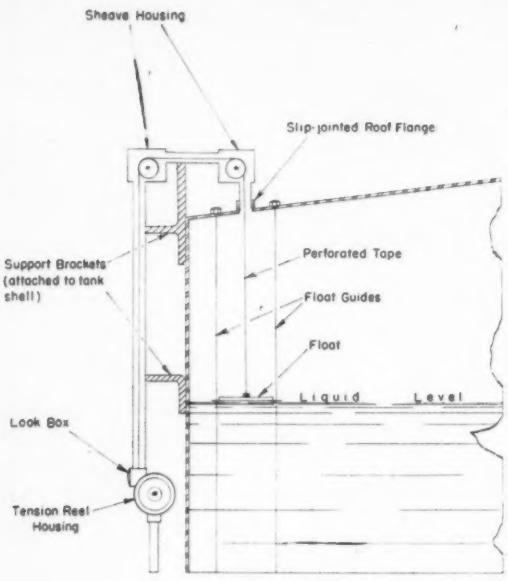

FIG. 1. Schematic diagram of typical mechanical float gage.

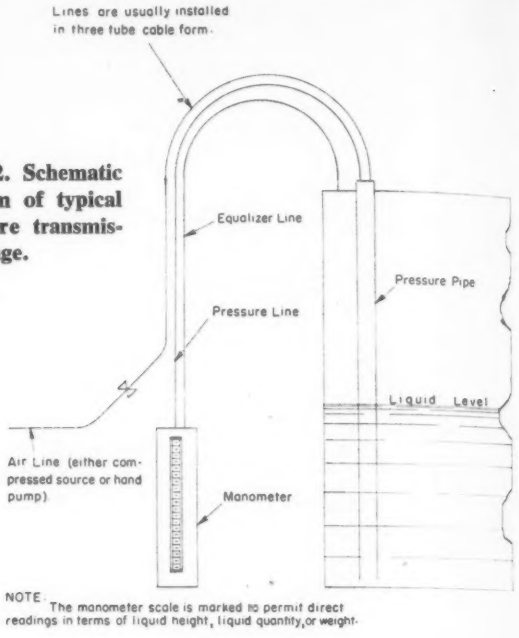
Lines are usually installed in three tube cable form.
Equalizer Line
Pressure Pipe
Pressure Line
Liquid Level
Air Line (either compressed source or hand pump)
Manometer
NOTE: The manometer scale is marked to permit direct readings in terms of liquid height, liquid quantity, or weight.

FIG. 2. Schematic diagram of typical pressure transmission gage.

OIL STORAGE

Measuring Temperatures and Levels

JOHN H. BERGLUND

PETROLEUM and its many liquid products are heterogeneous materials which have fairly high coefficients of expansion (ranging from 0.0003 to 0.0009 per deg Fahrenheit at 60 F) Thermal expansion or contraction causes appreciable volume variations, and therefore the petroleum industry has established the practice of calculating bulk quantities on the basis of volume at a standard temperature. This standard temperature is generally accepted as 60 F in countries where British or American units of measure are used, and 15 C in countries where the metric system is used.

The customer is billed for a "quan tity at the standard temperature" which is calculated from measurements of temperature and liquid level as determined and reported by the field gager. The correctness of the billable quantity is dependent upon the accuracy of the gager's data, regardless of the care which the accountant may exercise in making his calculations. Small errors in the field measurements of the average temperature of the tank contents or in the gage of the liquid level can result in significant losses to either the supplier or customer, especially when very large shipments are involved.

For example, in a small tank having a diameter of only 10 ft, the error associated with a difference of ⅛ in. in the liquid level amounts to about 6 gal, whereas the same error in a large storage tank having a diameter of 100 ft may amount to over 600 gal. In some areas, storage tanks with diameters as large as 150 ft are quite common and errors as small as ⅛ in. may represent as much as 1500 gal.

Errors in temperature determinations often are even more significant than gaging errors. Percentage-wise, they may appear to be small, amounting to about 0.03 to 0.09 per cent per deg F, depending upon the coefficient of expansion of the stock involved. This means, for example, that on a shipment of 50,000 bbl, the quantity involved for each degree F of error is between 600 and 2000 gal.

A cup case thermometer and a steel tape with a brass bob have been the standard equipment items for manual measurements for many years. The methods have been practically unchanged for over 30 years. In fact, a New York supply house still lists in its latest catalog an "oil gaging bob" which was illustrated in sales literature of the same company in 1911.

During the last few years there has been a considerable amount of develop-

The Author

John H. Berglund is affiliated with the Esso Laboratories Research Division of S.O.D. and has made an extensive study of the problems associated with bulk oil storage and measurement. A graduate of Wagner college with a BS degree in chemistry, Berglund joined Standard Oil Development Company in 1935. He is a member of ASTM Committee D-2 and secretary of its Division 2 on Measurement and Sampling.

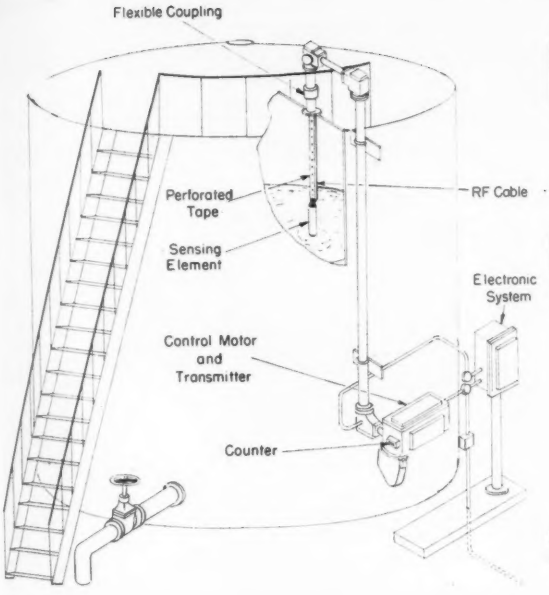

FIG. 3. Schematic diagram of electronic surface sensing device.

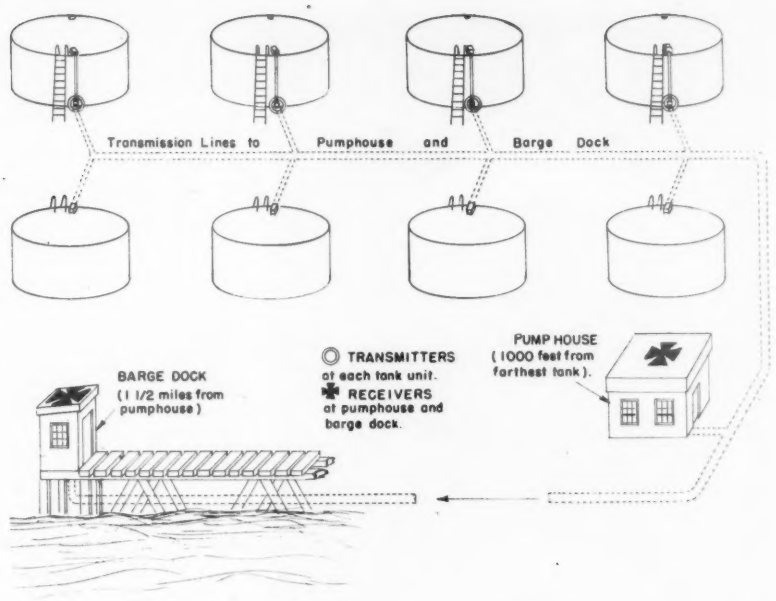
Transmission Lines to Pumphouse and Barge Dock
TRANSMITTERS at each tank unit.
RECEIVERS at pumphouse and barge dock.
PUMP HOUSE (1000 feet from farthest tank).
BARGE DOCK (1 1/2 miles from pumphouse)

FIG. 4. Typical tank farm application of remote control measurement system.

ment work on automatic devices for measuring temperature and liquid levels. Interest in such devices is increasing rapidly and it is anticipated that automatic systems may eliminate many of the problems now associated with custody transfer measurements. The writer does not mean to imply that manual methods are inaccurate. There are, however, certain advantages to be gained by the use of those automatic devices which are reliable and accurate.

Definition of Automatic Device

For the purpose of this paper, the term "automatic device" may be defined as an assembly that permits the determination of either the temperature or liquid level of the contents of a storage tank, without requiring any operation other than the manipulation of a knob, switch, or lever.

Automatic Devices

Advantages. The advantages to be gained by the use of automatic devices are difficult to evaluate precisely and do not apply necessarily to all operating conditions. Each case must be studied separately. The general advantages, however, may be summarized as follows:

Savings in Time and Manpower: Measurements of both temperature and liquid level can be taken in a matter of seconds simply by reading dials or counters. The only manual operation which may be involved is the manipulation of a knob, switch, or lever. The gager does not have to climb to the tank top. Also, if dirty products are measured, the time-consuming job of cleaning equipment is eliminated.

Most "manual" methods which are used for "referee' determination of temperature specify that an arithmetic average of 3 spot temperatures (top, middle, and bottom) taken with a cup case thermometer shall be accepted as the average temperature of the tank contents. Field data show that the cup case thermometer must often remain immersed for as long as 45 min in order to obtain a correct "spot" temperature of certain heavy heated products such as bunker fuel oil. Certainly, a procedure which may require a total time of more than 2 hours for the determination of an average temperature is not practical for many operations.

An automatic system also can be wired for the remote transmission of readings, thus eliminating the need for a gager to even visit the tank farm. The receivers can be installed in a pump house, superintendent's office, or other desired location.

In many cases the entire cost of an automatic installation can be justified on the basis of manpower savings or on a better utilization of existing manpower.

Improved Measurement Accuracy: Measurements obtained with an automatic system that has been properly installed and maintained, generally are more accurate than those obtained by manual methods in routine operations. The possibility of errors due to the human element are greatly reduced because of the simplicity of operation of most automatic systems. In particular, the automatic system is extremely advantageous when measurements are required during adverse weather conditions. Even a most conscientious and experienced gager is apt to make a mistake when measurements are required at such times as during freezing weather or in a severe rain storm.

Improved Operating Control: As measurements can be taken quickly and simply, an automatic system permits better operating control during filling and blending operations. The possibility of contamination or accidental "tank runovers" are reduced.

Although quicker comparisons with other measured quantities are permitted, the verification of tanker or barge loads may be made without delay. This in turn may result in quicker "turnarounds" for the vessels, with possible savings in demurrage charges. Delays due to severe weather conditions can be reduced because measurements can be taken in all types of weather.

Increased Tank Working Capacity: As an automatic system affords improved operating control, tanks may be filled to higher levels.

Reduced Evaporation Losses. Measurements can be made on tanks in crude or volatile product service without opening the gaging hatch to the atmosphere. It is estimated that, on tanks containing some high volatile stocks, vapors equivalent to as much as three gallons of liquid product may be lost to the atmosphere each time the gaging hatch is opened. Such losses can represent an appreciable amount on a cumulative basis for an active tank which is gaged frequently.

Improved Safety Conditions: The use of automatic equipment eliminates the possibilities of injuries to gaging personnel such as those caused by gass-

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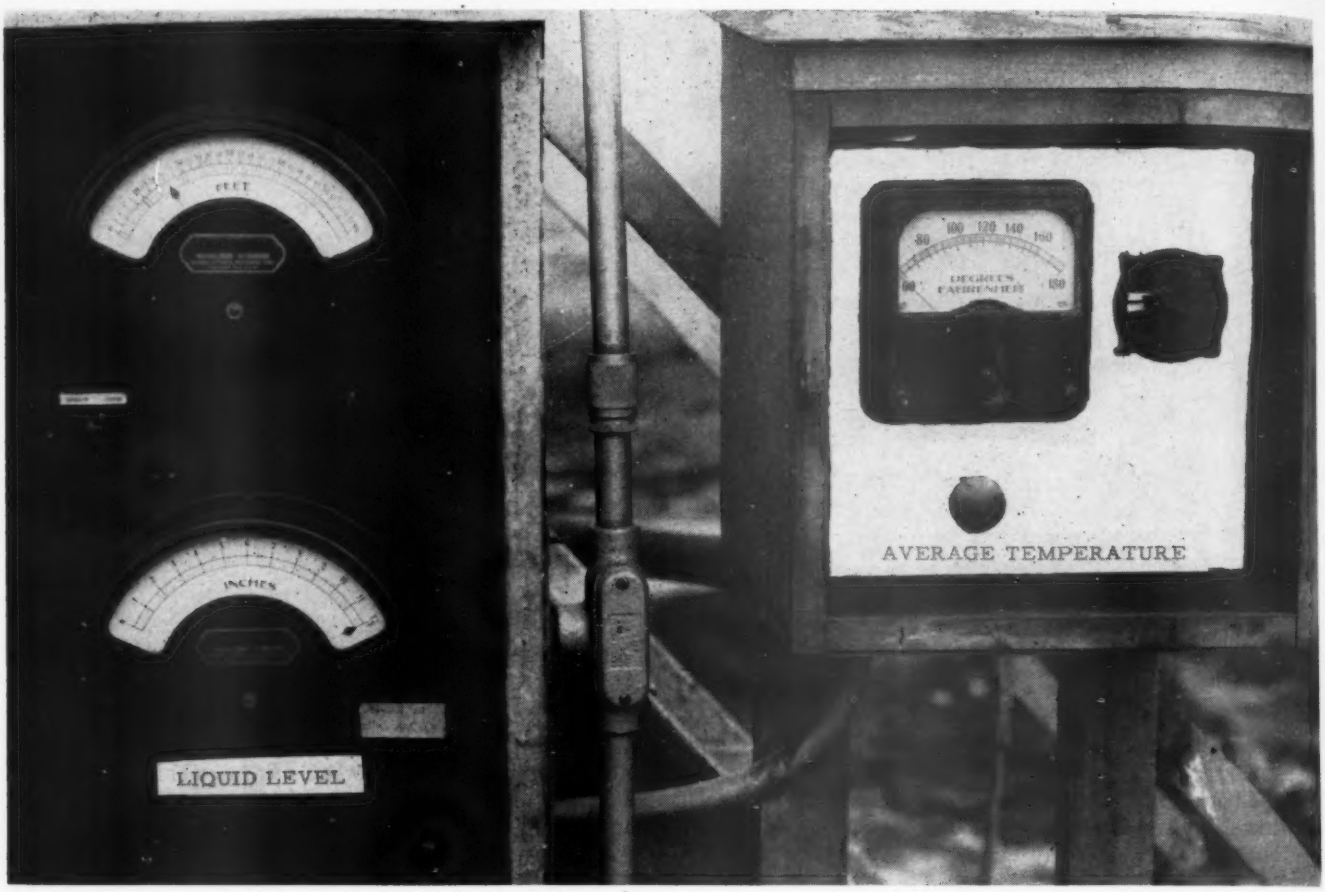

FIG. 5. Typical panel board — remote measurement receiver.

ing on tanks containing sour stocks, or by falls on icy ladders and stairways.

Disadvantages. Although it is believed that the advantages outweigh the disadvantages, all conditions must be studied before a decision can be reached as to whether an automatic installation is economically justified for a given tank. The disadvantages are:

Cost: The devices that are most suitable for accurate and reliable service usually are expensive. Obviously, the economic justification depends upon the throughput and frequency of measurements.

Maintenance: In order to attain a sustained accuracy within the required limits, maintenance inspections and checks on the automatic equipment must be made periodically and adjustments made when necessary. If electronic equipment is used, trained maintenance personnel may be required.

Water Bottoms: Although a considerable amount of development work is in progress, the writer is not aware of any automatic device, available on the current market, that is completely satisfactory for the accurate measurement of the level of water and sediment in tanks. Therefore such measurements must be made by manual methods, thus reducing the efficiency of a completely automatic system.

Liquid Level Gages

Several systems have been devised for measuring liquid levels and the basic principles are described herein. Of course, each manufacturer has made certain refinements and modifications to improve the accuracy and usefulness of the indvidual design. No attempt is made herein to describe these refinements in detail.

A conservative estimate is that there are at least 50 devices on the United States' market which can be classified as "Automatic Liquid Level Gages."

Mechanical Float Gage. The mechanical float gage is the most common type of automatic gage in use today. It consists of a float (usually made of aluminum, copper, 18-8 stainless steel or Foamglas) connected to a steel tape or cable which passes over a system of sheaves in such a manner that the liquid level is in direct relation to the position of the float (Fig. 1.). Tension, sufficient to keep the tape or cable taut, is applied to the free end, usually by means of a counterweight or by winding it onto a spring loaded reel. The liquid level is indicated on a dial, Veeder-type counter, or, graduations on a tape may be read directly against a reference pointer in a "look box." When dials or counters are used, the drive is usually actuated by a system of gears or a magnetic clutch operated by (a) a toothed drum fitted to perforations in the tape, (b) cable arrangements, or (c) movement of the spring loaded tension reel.

These devices are relatively low in cost and most models can be equipped for remote transmission of the readings.

A disadvantage of the mechanical float gage is that the submergence of the float may be affected by differences in specific gravity of the product being measured. This condition occurs when there is a wide variation in product temperature between opening and closing measurements or when the tank service is switched to a product of a different specific gravity range. Also, in areas where high frost conditions prevail, the sheave system may bind or freeze, thus causing the device to become sluggish or inoperative.

Most manufacturers have provided means of compensating or adjusting for specific gravity variation and, with proper maintenance, an accuracy within a tolerance of $\pm 1/8$ in. is possible with a properly designed float gage. This accuracy usually is satis-

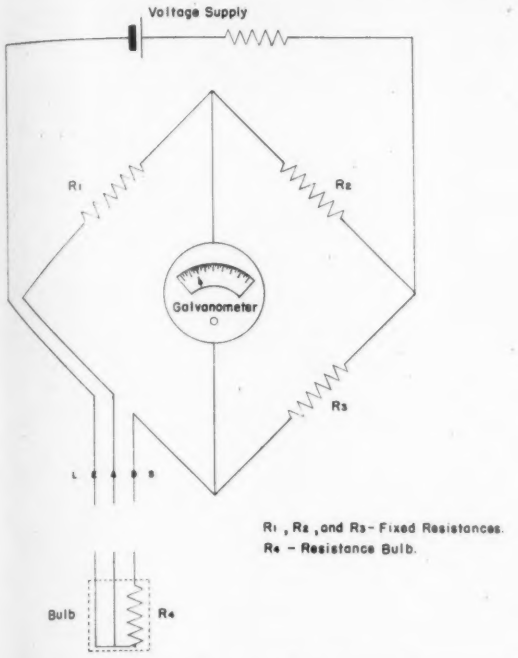

FIG. 6. Basic wiring diagram of resistance thermometer circuit.

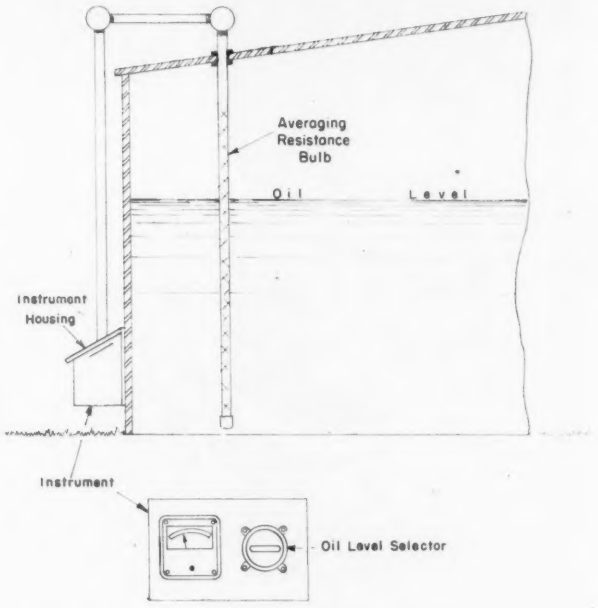

FIG. 7. Typical installation layout for averaging type resistance thermometer (cone roof tank).

factory for installations on tanks having diameters less than 100 ft.

Pressure Transmission Gages. There are a number of devices on the U. S. market that operate on a pressure transmission or hydrostatic principle. These gages actually measure the weight of a given liquid column by balancing it against a pressure equal to that of the liquid head (Fig. 2). The balance is actuated by introducing air into a pressure pipe until the pressure is equal to that of the liquid head. A reading equivalent to this pressure is indicated on a manometer of either the liquid or aneroid type or on a dial indicator actuated by a pressure bellows, capsule or diaphragm. The instruments can be calibrated so that direct readings can be obtained in terms of liquid height, liquid quantity, or weight.

The devices are designed primarily for small tanks. Multiple installations should be made if they are used to measure the contents of large tanks. In general, a separate gage for each 10 ft of tank height usually is required in order to achieve the desired degree of accuracy. As the devices actually measure the weight of a liquid column, the actual specific gravity of the tank contents at the observed temperature must be known in order to calculate accurately the liquid quantity at a standard temperature such as 60 F or 15 C.

The devices are relatively low in cost (about $100 for each unit plus installation) and can be installed for remote indication at reasonable distances (up to 1500 ft) from the tank without the use of a special transmission system.

Electrical Devices. A few electrical and electronic liquid level gages have been developed and it is anticipated that devices of these types probably will be the ultimate solution to the measurement problem. They are expensive at the present time but increases in production and usage, as well as market competition, should result in reductions to reasonable price levels in the very near future. It is important to note that instrument manufacturers are well aware of the need for devices of this type and a considerable amount of development work is in progress.

Basically these devices consist of a **contact probe or surface sensing element** which is suspended over the oil level. Electrical impulses or signals (from the probe or sensing element) control a two-phase motor which raises or lowers the probe or element as the liquid level changes. A schematic diagram of a typical device is shown in Fig. 3.

The writer's experience during the past 2 years with an electronic device of the surface sensing type indicates that it is extremely sensitive and accurate when maintained properly. If the device is kept in good condition, the overall accuracy should be well within a tolerance of $\pm 1/16$ in.

Other Methods. Several other systems for liquid level measurement have been devised, or are under development, and may become prominent in the near future. These systems involve the following principles:

(a) Gamma radiation
(b) Sonic vibration
(c) Radio frequency

Transmission Systems. A number of very excellent systems have been developed for remote transmission of liquid level measurements. By means of a transmitter located at the tank, as part of the gage assembly, the readings are transmitted electrically or electronically to a receiver located at a desired remote point. The readings are indicated on a panel light board. Veeder-type counter or dials, depending upon the system used.

The systems may be classified as follows:

(a) Impulse motor
(b) Single or double selsyn
(c) Electrical step contact
(d) Wheatstone bridge electronic
(e) Balanced input electronic
(f) Impulse scanning

Although a separate transmitter is generally required for each tank installation, one selective type receiver usually can be used for a group of tanks. Transmission to more than one remote point is possible also with some systems. A typical tank farm application is illustrated in Fig. 4 and a typical receiving panel is shown in Fig. 5.

Temperature Devices

The problem involved in determining the temperature of the contents of

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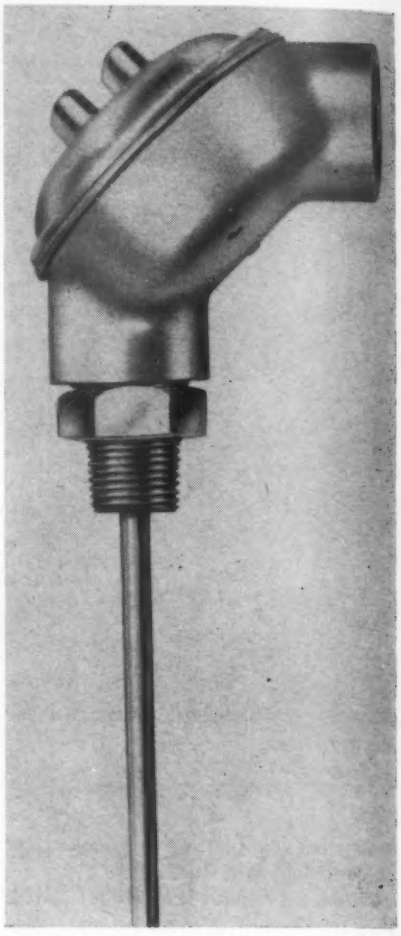

FIG. 9. "Spot" type of resistor.

storage tanks are more complex than those associated with the measurement of liquid level. This probably accounts for the fact that only a few types of automatic temperature devices have been developed.

Electrical Resistance Thermometers. The electrical resistance thermometer appears to be the most satisfactory instrument in terms of practicability and accuracy. It can be applied to the determination of either "average" or "spot" temperatures in various types of containers and carriers, including pipe lines.

The instrument is based on the principle that certain metals, such as copper, nickel, silver, and platinum have the property of changing their electrical resistance uniformly with changes in temperature. This property is used to determine temperature by measuring the change in resistance of a wire resistor located where the temperature determination is desired.

The basic wiring diagram for a resistance thermometer is shown in Fig. 6. It consists of a Wheatstone bridge resistance network made up of 3 units of fixed resistance and a 4th unit placed where temperature determination is desired. Each of these units has a resistance of 100 ohms at 25 C.

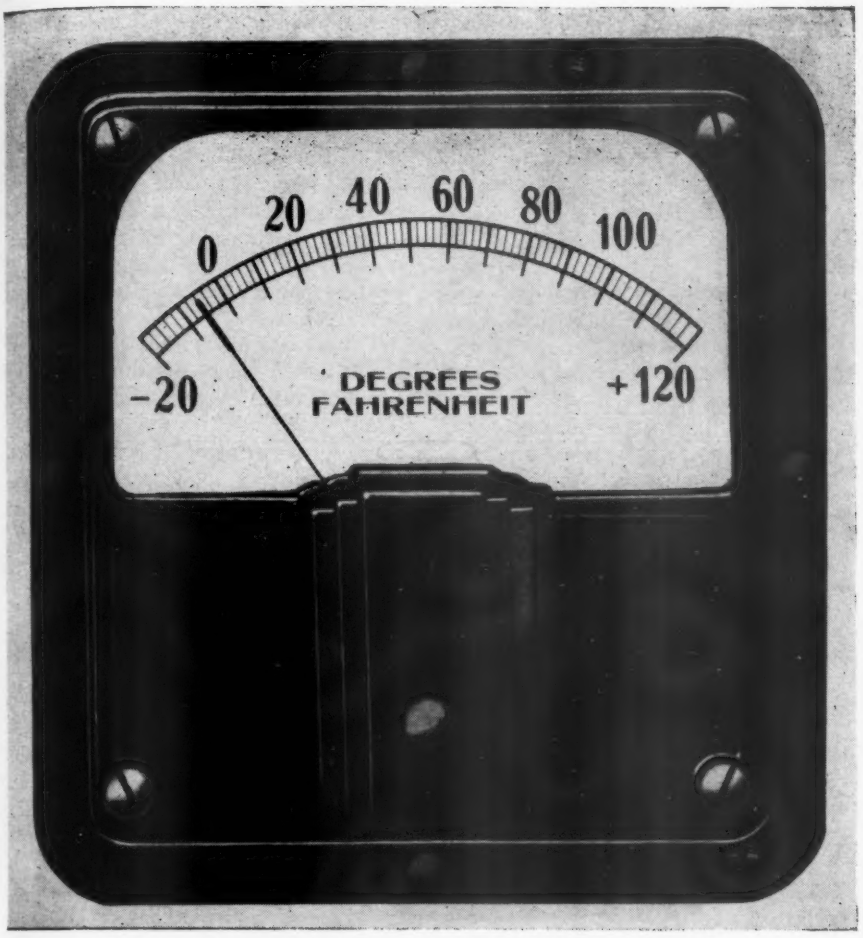

FIG. 10. Typical indicator dial of electrical resistance thermometer.

A ratio type galvanometer, or its equivalent, is used to measure the balance of the bridge, the galvanometer dial being calibrated in terms of temperature units, F. The voltage supply is 6 v d-c supplied by batteries (four 1½ v dry cells) or from a 110 v a-c circuit stepped down to 6 v d-c by a "built-in" rectifier and transformer.

A three-wire circuit is used to nullify any errors which may be caused by the resistance of the lead wires. The cur-

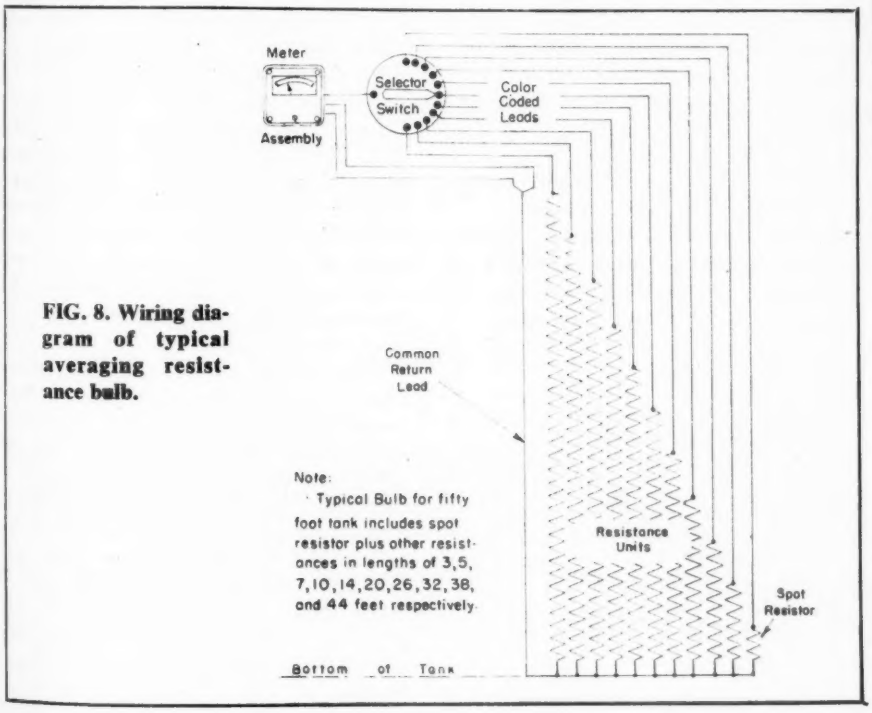

FIG. 8. Wiring diagram of typical averaging resistance bulb.

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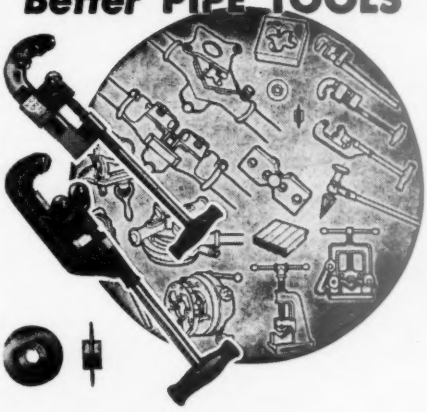

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rent is applied directly to the temperature bulb (the fourth resistor) and a third lead from this junction carries the voltage back to the bridge.

To determine the average temperature of an oil body in one reading, a long resistor must be suspended vertically so that the differences in temperature are distributed proportionally along the resistor. The oil level in a tank is not constant (i.e., it rises or falls as oil is pumped into or from the tank) and, therefore, the resistor length must change with the oil level. To accomplish this, there are several ideas for resistor design. (float arrangements, collapsible resistors and so forth). The most practical, however, is a bundle of resistors (of various length but each of equal resistance) connected to the meter by means of a selector switch.

By means of this switch, a resistor in the bundle, which is approximately the same length (vertically) as the depth of oil, but completely submerged, can be connected to the meter assembly and the average temperature determined in one reading. The switching can be done automatically, if desired, by using a series of cam type switches that are operated by an automatic gage. As the "drive" is mechanical, gages of the pressure transmission type are not adaptable.) The automatic switch is particularly advantageous when remote transmission is desired, as the number of wires required for transmission is reduced to a minimum.

The bundle of resistors is called the **Averaging Bulb** and consists of the number of resistors which will cover the range of oil levels for a given tank. Each resistor is sealed in a thin-walled plastic tube and the bundle is inserted in a ½-in. flexible metal hose. The hose assembly is suspended vertically in the tank (Fig. 7).

Fig. 8 shows a wiring diagram for an averaging bulb. Each resistor has a color coded lead that is connected to the selector switch. A common return lead connects to the bottom of each resistor and then branches to two black leads, one of which connects to the voltage supply and the other to the bridge. A connection from the selector switch to the opposite arm of the bridge completes the circuit.

A spot temperature can be obtained by using a short resistor, usually about 2 to 4 in. long, encased in a thin-walled monel metal tube, Fig. 9. Several of these "spot" bulbs can be installed at suitable locations in a tank or pipe line and connected to a selector switch which is used to connect the desired bulb to the bridge or meter assembly.

The galvanometer dial (Fig. 10) can be calibrated for any convenient range of temperature. However, in order to maintain a sustained accuracy of ±½ degree F, it usually is practical to limit the scale to about 125 units of Fahrenheit degrees.

The meter assembly (including the manual selector switch) can be located at the tank or at a remote point such as a pumphouse, gager's shanty, or superintendent's office. The instrument is rugged and requires little or no maintenance.

Thermocouples. Thermocouples are designed on the principle that, in a closed circuit of dissimilar metals, a current is generated when the junctions are at different temperatures. The current is measured with a millivoltmeter or galvanometer, the scale of which is calibrated in terms of temperature units, F or C. Large wires are used so that errors caused by changes in resistance (due to temperature) of the wires will be minimized.

Although these devices have been used successfully for determining spot temperatures on certain test installations, they are not particularly adaptable for determining temperatures in the range of normal petroleum storage. Many compensating factors must be introduced in the measurement of temperatures below 300 F and such compensation requires complicated and expensive instrumentation.. Future developments may overcome or simplify these disadvantages, however. The device has a definite advantage in that it is adaptable for a recording type of remote transmission. Temperatures can be recorded automatically on either a "continuous" or "time interval" basis.

Stationary Thermometers. Certain installations of industrial type thermometers can be classified as "automatic" since no manipulation or other operation is required except to read a scale or dial. These thermometers are installed permanently in a tank by using a standard metal well or socket. They are used to determine spot temperatures and readings cannot be transmitted to a remote point.

The following types of thermometers are included in this classification:

(a) Angle stem industrial type thermometer (glass)
(b) Bi-metal actuated dial type thermometer
(c) Mercury actuated dial type thermometer

The stems of these thermometers should be about 36 in. long and the sensitive portion of the stem should not exceed 2½ in. The accuracy is about 1 per cent of the range over the entire scale.

Other Systems. Other systems and applications, such as long sensitive capillary tubes (both gas and mercury filled), and under study and may become prominent in the future. The practicability of such devices must be evaluated on the basis of accuracy, installation details, simplicity of operation, maintenance, and cost.

Conclusions

The general use of automatic devices for custody transfer measurements is being accepted gradually but with caution. A few major companies are using them for intra-company transactions. Present use for "outside" transactions, however, is limited to cases where mutual agreement with the customer has been specified in the purchase contract.

The devices probably will not be used to a great extent until (1) supporting field test data have been published to establish the accuracy and maintenance required, and (2) standardization agencies have included applicable information and specifications in the recognized standard measurement procedures.

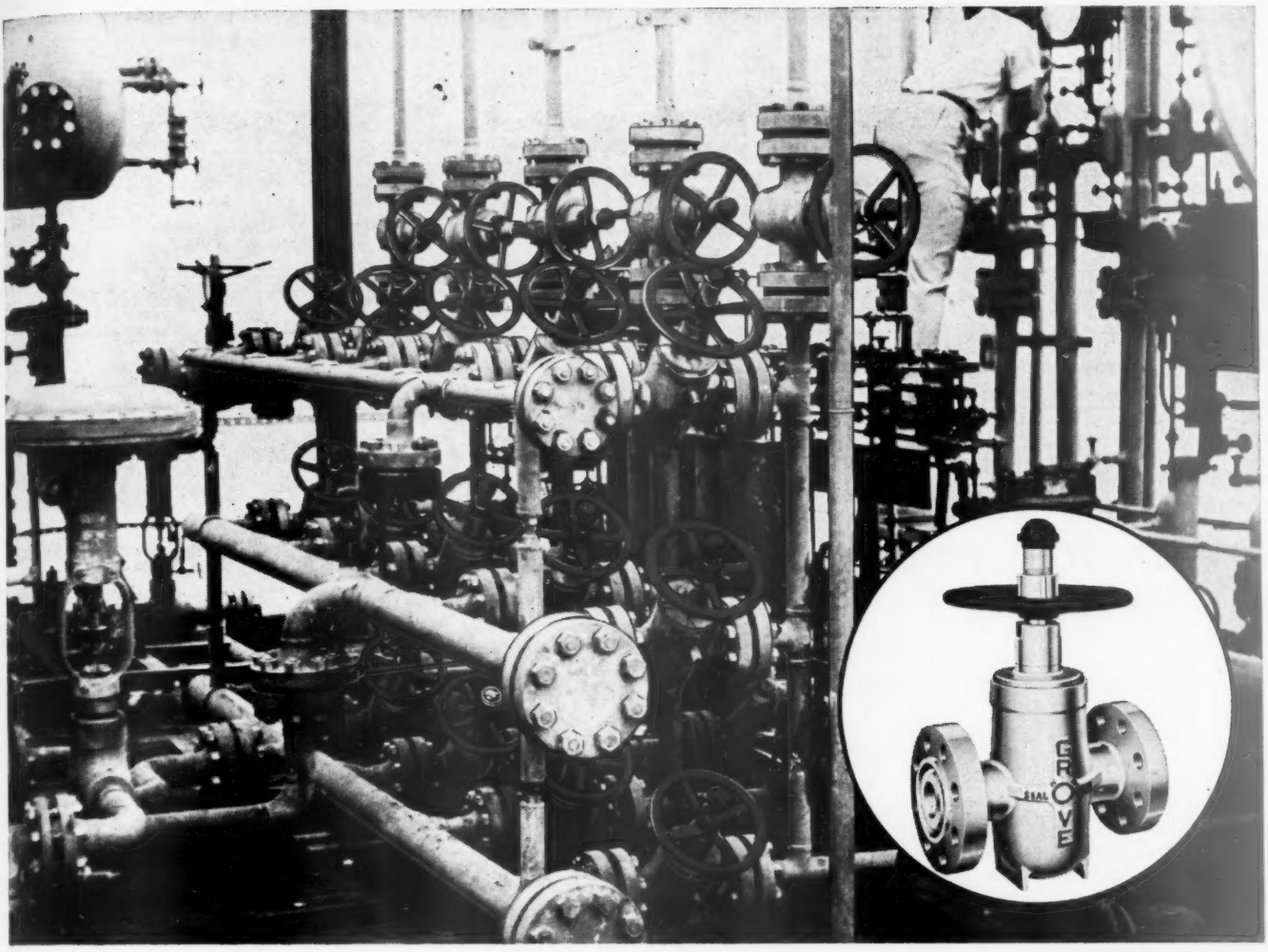
All of the devices described herein are being studied by measurement groups of the American Society for Testing Materials and the American Petroleum Institute. These groups are preparing drafts of minimum specifications for automatic devices and it is anticipated that definite recommendations will be made in the very near future. The publication of these recommendations and minimum specifications in various industrial measurement codes should spur on the general acceptance. It should promote also further research and development by the instrument manufacturers to improve the present models.

The use of automatic devices may seem to be a revolutionary step but the potentialities are almost beyond comprehension. Today, automatic measuring devices, pumps, and even valves can be installed for remote operation. Tomorrow, perhaps an electronic calculator will be added to the system so that an entire shipment will be measured, transferred and the billable quantity calculated by manipulating simple push-button controls at a centralized location. * * *

U. S. Plans Business Census

About 3,000,000 establishments engaged in distribution, manufacturing, and mining will be canvassed by mail early next year in the censuses of business, manufacturers, and mineral industries by the U. S. Department of Commerce.

Census of mineral industries will cover operations of about 35,000 establishments engaged in mining, petroleum producing, and quarrying. Information on output, employment, payrolls, fuels, power consumption, and other items will be published for states and all counties with important mineral industries.



Grove Seal "O" Ring Gate Valves replace other valves at Red Fish Bay installation

The photograph above shows a portion of one of three flow manifold platforms at Red Fish Bay. This one was originally equipped with Grove Seal-"O"-Ring Gate Valves, which performed without leak or maintenance even from the very first, when subjected to the mud and sand carried up by the initial flow of gas.

Competitive valves on the other two platforms soon failed under similar operating conditions. As their replacement rapidly became necessary, Grove Seal-"O"-Ring Gate Valves were installed because of the performance record established on the first platform.

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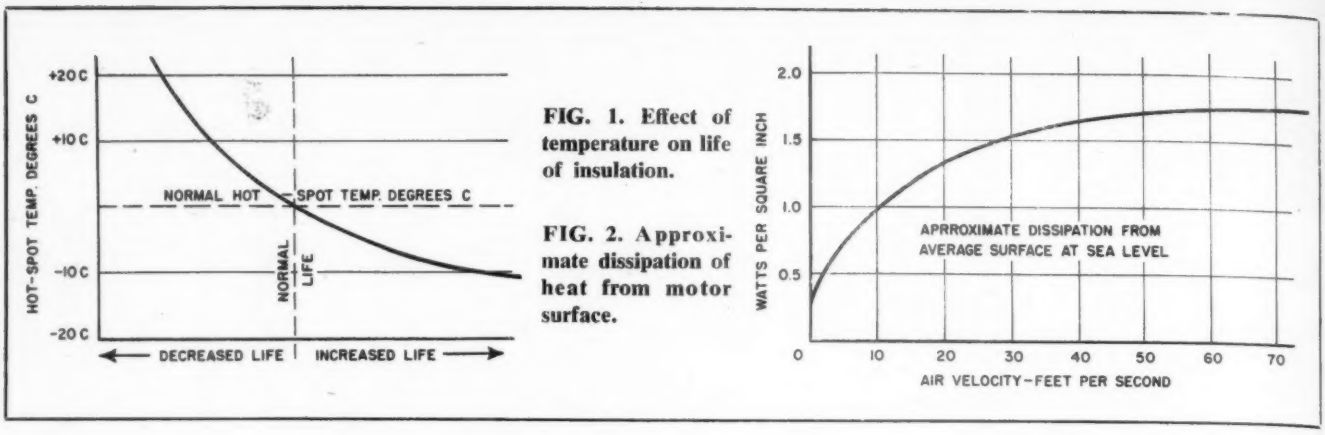

FIG. 1. Effect of temperature on life of insulation.

FIG. 2. Approximate dissipation of heat from motor surface.

Enclosures For Protecting Large Motors

Wide variety of types required by the many prevailing ambient conditions

G. L. OSCARSON and R. J. KOLAR

A LARGE electric motor is an efficient means of converting electrical input to mechanical output; however, in the process, the ensuing losses are converted into heat. This heat must be be removed, usually by passage of cooling air over the exposed surfaces, to prevent temperatures that might be damaging to the motor insulation.

Such a motor has a multiplicity of conductors that must be insulated from each other and from other adjacent metal parts (referred to as "ground"). The life of this insulation or, in effect, its ability properly to insulate such conductors is a function of the hot-spot temperature, and the length of time it has been in operation. Fig. 1 illustrates approximate relationship of insulation life and variation in hot-spot temperature.

An exposed surface, in still air, will dissipate only a relatively small amount of heat. This dissipation can be increased appreciably by sweeping the surface with an air stream. Fig. 2 illustrates the approximate heat dissipation, from an average surface, at various air velocities and at temperature differentials common to motor applications.

For many years, large motors were built with no restrictions to the entrance of air, or other matter, other than those necessitated by the mechanical construction and support; however, a realistic evaluation of ambient conditions frequently prevailing led to the development of a wide variety of enclosures. These are grouped in two general classes as defined by NEMA: MG1-1.13 Open Machines, which permit the passage of cooling air over and around the windings; and MG1-1.14 Totally Enclosed Machines, which prevent free passage of air between inside and outside of the case, but which are not air tight.

The Authors

G. L. Oscarson R. J. Kolar

G. L. Oscarson is chief application engineer of Electric Machinery Manufacturing Company. He is responsible for coordination of application requirements of all large power equipment. From 1923 to 1940 he specialized directly in the application of motors and generators as a field engineer. Oscarson is a graduate of the University of Minnesota.

R. J. Kolar is mechanical design engineer for Electric. A graduate of the University of Wisconsin with a degree in mechanical engineering Kolar was formerly with Burke Electric Company (now Marathon). He joined Electric in 1952.

Reasons for Enclosures

Ambient conditions that call for some form of enclosure may be dripping or splashing liquids, moisture, oil vapor, dust, abrasive or conducting particles, corrosive fumes or explosive gases.

Open type motors, installed outdoors, require ventilating passages designed to minimize the entrance of rain, snow, or air-borne particles. This is provided in weather-protected construction.

Abnormally high ambient temperatures may call for totally enclosed motors and air coolers; likewise the concentration of a large amount of horsepower in a relatively small space may require use of either air coolers or of discharge ducts to carry the heated air outside the motor room.

In some cases motors are partially or totally enclosed to minimize the transmission of noise.

Ventilation Principles

Most large motors are self-cooled in that they move the cooling air by means of fans or blowers integral with the rotor. When filters and a long intake duct are involved, or when the intake duct must be kept under positive pressure to prevent possible entrance of explosive gases, and the motor enclosure must be purged before

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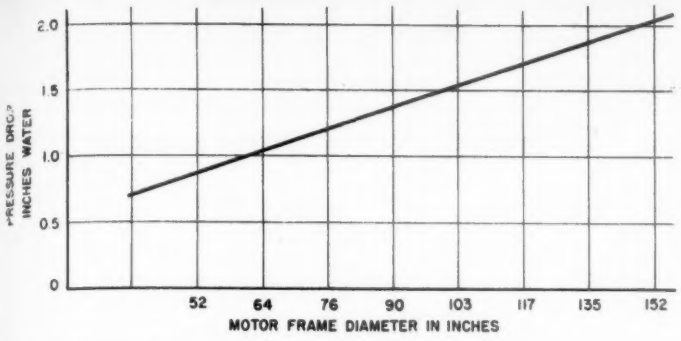

FIG. 3. Approximate relationship of frame diameter to air pressure drop in large motors.

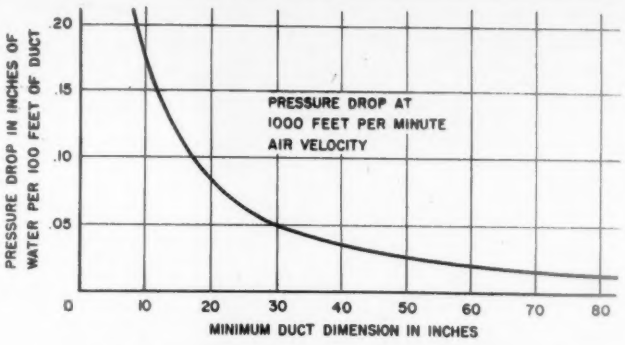

FIG. 4. Relationship between minimum duct size and pressure drop for 1000 fpm air velocity.

the motor is started, a separate motor driven blower, located in non-explosive air, is required.

Blowers for forced ventilation are of high-speed, single-stage type, usually with the rotor mounted on the drive shaft. Driving motors are usually of explosion-proof construction.

To assure complete safety it is necessary that the fan motor be started first and the complete cooling system be purged before the main motor is started. The "start" button, therefore, starts the blower motor only, and a timing relay energizes the main motor control after a suitable interval of time. If the blower motor shuts down for any reason the main motor also shuts down.

The amount of cooling air required varies from 75 to 125 cfm per kilowatt of loss depending on the allowable temperature rise and the effectiveness of the cooling system. The following relationship between losses and cooling air temperature rise applies:

$$\text{Degrees C rise at 40 C} = \frac{1900 \times \text{kw loss}}{\text{cfm}}$$

The pressure drop through a motor will vary in proportion to the frame diameter. Fig. 3 illustrates approximate relationship of frame diameter to air pressure through large motors.

Where duct intake or exhaust is required the duct area should be such that the air velocity will be in the range of 800 to 1200 ft per min. For

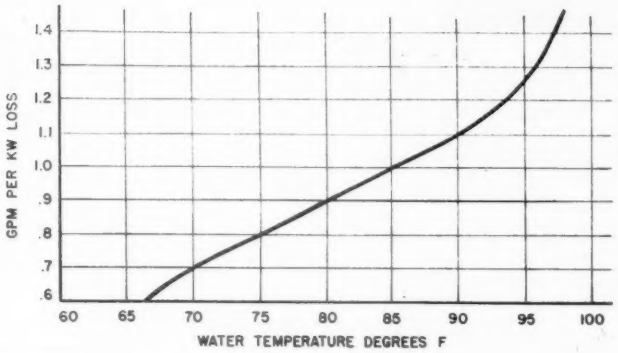

FIG. 5. Approximate cooling water requirements per KW loss for various ambient water temperatures.

a first approximation the pressure drop in such a duct is a function of air velocity and of the minimum duct dimension. Fig. 4 illustrates the relationship, at a velocity of 1000 ft per min, between minimum duct dimension and pressure drop. For any given duct the pressure drop will vary as the square of the air velocity.

When filters are used their area should be such that the air velocity through them is in the range of 300 to 500 ft per min. At that velocity the pressure drop through a filter is approximately 0.1 in. of water. In conventional filters this inceases as they become clogged and they should be replaced when the drop becomes 0.3 in. to prevent excessive reduction in cooling air flow. Non-clogging filters are available. The drop across them does not materially increase as they become clogged but the filtering effectiveness decreases.

In some cases an intake room with filtered sides is necessary in order to obtain acceptable air velocities through the filters. In other cases the intake duct can be arranged with sufficient filter area as shown in Fig. 7.

Types of Protected Motors

The various types of motor protection are covered by NEMA definitions. These are so well known it is not felt necessary to repeat the definitions here; however, the following application comment may be of interest.

Enclosed self-ventilated motors are frequently used as room intake, duct-discharge outside of the motor room, in locations where there is considerable concentration of energy in a relatively small area and it is desirable to dis-

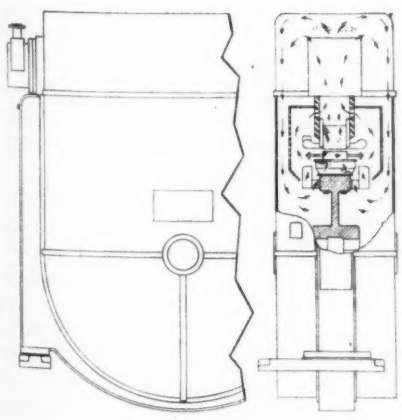

FIG. 6. Totally enclosed water-cooled engine type motor cooler mounted on top of motor. Ventilating air is recirculated from motor to cooler by fans on rotor. Motor can be pressurized with inert gas or instrument air.

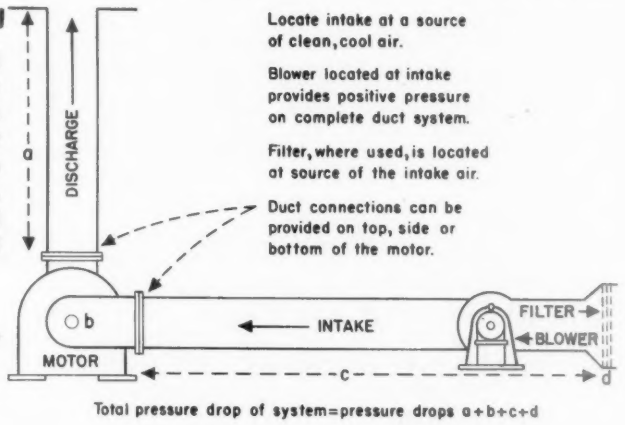
a
DISCHARGE
Locate intake at a source of clean, cool air.
Blower located at intake provides positive pressure on complete duct system.
Filter, where used, is located at source of the intake air.
Duct connections can be provided on top, side or bottom of the motor.
b
INTAKE
FILTER
BLOWER
MOTOR
c
d
Total pressure drop of system=pressure drops a+b+c+d

FIG. 7. Duct system for enclosed forced ventilation.

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Heavy Duty Wheel and Roller

★ Positive clean-cutting action.
★ Hooks on pipe easily . . . tracks perfectly . . . sturdy malleable frame formed to fit the hand and guaranteed warp-proof.
★ High alloy steel cutter wheels leave practically no burr.
★ Rollers in hook provide a square base when starting tool on pipe. Cuts ⅛" to 2" pipe . . . with speed and ease! Order through your supply house. Write for new catalog. The Toledo Pipe Threading Machine Co., Toledo, Ohio.

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TOLEDO

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PIPE TOOLS

TABLE 1.

Type of enclosure	Ventilating accessories	Application considerations	Approximate cost ratio
Dripproof	None	Minimum recommended protection except for slow speed or compressor motors.	100 per cent
Splashproof	None	For installation in moist locations, especially where motor is subject to splashing or hosing down.	115 per cent (50 C temp rise) 130 per cent* (40 C temp rise)
Enclosed self (pipe) ventilated	Inlet duct or discharge duct or both	The sum of the pressure drops in the inlet and outlet ducts (including any attached filters, etc.) must not exceed limiting values depending on motor rating.	125 per cent 50 C temp rise) 140 per cent* (40 C temp rise)
Enclosed separately (forced) ventilated	Motor-driven blower, inlet and/or discharge duct. Filters optional	Used to provide motor with source of clean or cool air. May be used in some hazardous explosive locations when blower and inlet duct can be placed in non-hazardous location.	108 per cent*
Enclosed self-ventilated with water cooling	Air cooler and enclosure	Used for protection against carbon black, metal scale or other air-borne material. Used where ambient temperature is excessive or where it is impracticable to discharge heat into motor room. May also be used to minimize noise.	160 per cent*
Enclosed self-ventilated with inert gas cooling	Inert-gas filled, with shaft seals, cooler, enclosure and protective devices	For installation in areas where explosive gases may be present and where a source of non-explosive ventilating air is not conveniently available.	180 per cent*
Totally-enclosed fan-cooled	TEFC enclosure	Usually for installation outdoors.	205 per cent* (55 C temp rise)
Explosion proof	Explosion resisting enclosure and flame retarding shaft seals	For installation in areas where explosive gases are present. Not used in large frame sizes.	225 per cent*
Weather protected	Enclosure to minimize entrance of rain, snow or air-borne particles. filters optional	For all outdoor applications. With SIL-CLAD corrosion resistant Sili-cone insulation and Silicone metal coating, the motor is especially adaptable to wet, salt air and corrosive locations.	125 per cent* (50 C temp rise) 140 per cent* (40 C temp rise) 150 per cent* (SIL-CLAD protection) (70 C temp rise)

* Percentages are approximate and will vary with horsepower, speed, and type of motor.

charge the heated air outside the motor room. Provision must be made for entrance of cooling air of sufficient quantity into the motor room.

Enclosed separately ventilated motors are used, usually with intake filters, in explosive locations, and in locations where conducting particles may be present in the cooling air. Carbon black has an especially detrimental effect on insulations; however, filtering and forced cooling is usually not so effective in minimizing the effects of carbon black as a totally enclosed water-cooled motor.

Water-cooled motors, large, totally-enclosed, are usually equipped with heat exchangers, regardless of whether they are air-cooled, or filled with inert gas as protection against infiltration of explosive gases.

These are closed circuit motors in that the same cooling air is recirculated continuously within the casing. After passing through the motor the air passes finned tubes through which cooling water flows.

Coolers may be either top, side, or bottom mounted, depending on space requirements. Coolers normally have Admiralty tubes, Muntz metal tube sheets, and cast-iron or fabricated steel water boxes; however, the presence of corrosive elements in the cooling water may call for non-corrosive cooler construction.

Amount of cooling water required per kilowatt loss is a function of cooler area and of water temperature. A typical cooler to dissipate 30-kw loss (102,200 btu per hour) has a tube surface, including fins, of 514 sq ft and requires 30 gpm of 85 F water. Such a cooler while passing 3600 cfm will lower the air temperature from 131.4 F to 104 F, with a pressure drop of 0.38 in. water; the water temperature rises from 85 F to 91.8 F with a pressure drop of 9 ft.

Inert gas-filled, water-cooled motors, used in areas where explosive gases are present, are equipped with shaft seals, and normally operate at an internal gas pressure of 1½ in. of water. Nitrogen is commonly used as the cooling medium and positive pressure, to prevent infiltration of explosive gases, is automatically maintained within the casing. If the internal pressure drops to 1 in. an alarm sounds, and at ½ in. the motor automatically shuts down.

Instrument-air filled motors can also be used for protection in hazardous areas. This is a totally-enclosed, water-cooled motor that is pressurized with fresh, clean instrument air.

Sil-clad motors, totally-enclosed, fan-cooled motors frequently prove impracticable in extremely moist locations due to internal moisture accumulation resulting from "breathing" during temperature changes. Salt-spray or acid-laden air frequently corrodes cooling tubes and fans on motors of this construction. Silicone insulated coils and silicone coated metal parts are resistant to such conditions. A recent development has been the substitution of Silicone weather-protected motors for totally-enclosed fan-cooled motors for outdoor installation in corrosive locations. The Silicone protection is available on other types of motors also.

* * *

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Recruiting Supervisor, Box 59

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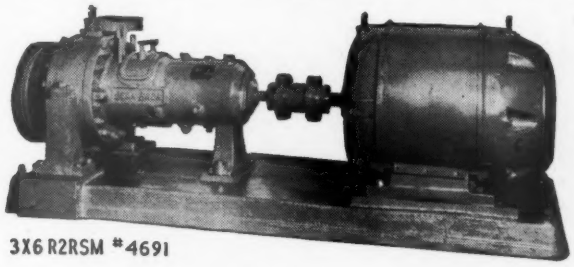
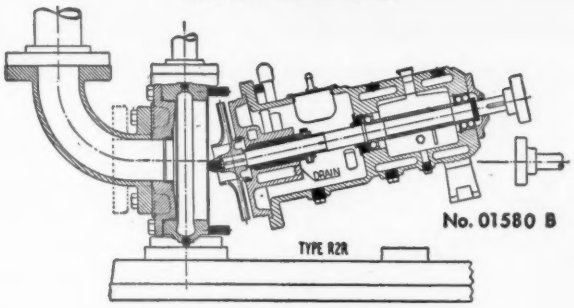
Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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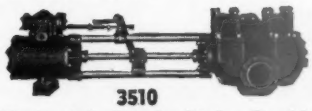
CENTRIFUGAL AND RECIPROCATING PUMPS

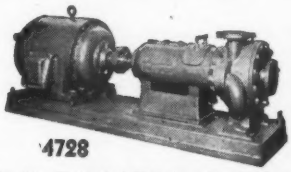
Close Coupled Centrifugal Pump



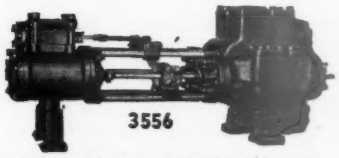
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



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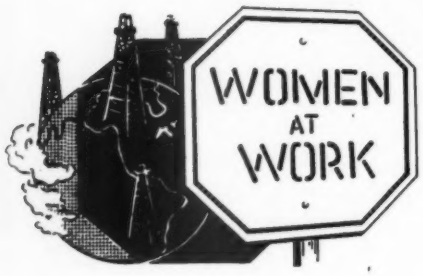
To obtain more information on products advertised see page E-57

Mrs. Merryman holds key oil job with Texas Railroad Commission.

Esther Lyman is assistant corporate secretary of the Ethyl Corp.



Expert in "Trouble Shooting"

Elma Merryman brought over a quarter-century of experience with her when she joined the Railroad Commission of Texas in 1932. She cut her business teeth as a deputy county clerk in Comanche County, Texas, and, so far as she knows, is the first woman ever to serve in such a capacity. Her next job was in Fort Worth; later she migrated westward and assisted in compiling abstracts on every tract of land in Terry County. Then she got into the publishing business and for several years owned and managed a weekly newspaper in Brownfield.

Mrs. Merryman's first job in Texas' capital city was as secretary to the State Department of Agriculture. She moved to the position of secretary and clerk in the State Senate and from there joined the Game, Fish and Oyster Commission. Elma had her eye on the oil industry for a long time before a job opened in the Oil and Gas Division of the Railroad Commission in 1932. The job was offered and she grabbed it.

"Our section of the Oil and Gas division is commonly known in oil circles as Rule 37 or trouble-shooting department. A rule 37 permit is necessary only when the location sought violates the spacing rules." Mrs. Merryman has written more than 15,000 drilling orders as exceptions to Rule 37 since she joined the Commission 21 years ago.

Special hearings are held on all Rule 37 applications and complete records of all proceedings must be taken, later transcribed and typed. This is also Mrs. Merryman's task. She delivers the completed records to the Commission and from the reports, permits are granted or denied.

You'd think that all these duties would be sufficient to keep any lady busy, but not Mrs. M. She is a member of choir of Hyde Park Baptist Church in Austin and often is pianist, too. She is a member of the North Austin Civic Club, of Desk and Derrick and of the Eastern Star; has held a number of important offices in the latter group, twice in the Grand Chapter of Texas.

Ethyl Corporation Officer

The first and only woman officer of Ethyl Corporation, New York, is an attractive young woman with an efficient mind and a generous smile. Esther Stapley Lyman joined the company in 1940 as secretary to the corporate secretary. Her duties have included employee relations, benefit plans, job classification, charting, orders and shipments, sales, forecasts and office layouts. She is now assistant corporate secretary of the company.

Her most unusual accomplishment has been in organizing and indexing all minutes of Ethyl from its incorporation in 1924. This has abolished the former procedure of searching through old records and saves countless hours. She has also set up an index to corporate contracts and a follow-up of expiration dates. Her present duties include gathering background material for the board of directors and management committees, preparation of minutes, responsibility for corporate contracts, for official records of patents and trade marks, and the arduous task of applying the corporate seal to official Ethyl documents.

"This is the *biggest* job I have!"

The wife of advertising account executive, Parmelee Lyman, and the mother of 11-year-old Edith, Esther started with Ethyl after graduating from Vassar College and Katharine Gibbs Secretarial School. She and her husband commute daily to New York from Stratford, 65 miles away. The trip takes one and a half hours each way and for the past 3 years Esther has utilized the time to study law from LaSalle Extension University.

Esther's off-duty schedule runs to feminine activities. She sews — makes all her own draperies and slip covers and some of her daughter's clothes — cooks, collects recipes — plans to index them one of these days! — and collects salt and pepper shakers. She is an enthusiastic booster of the Desk and Derrick Club.

Set Up File System

Lucille Dutton didn't exactly build a better mousetrap, but she did set up a better filing system. And now industry and college is beating a path to her door to find out how she did it and how the system works.

Officially Lu is in charge of the Central Files Department of Esso Standard Oil Company in Baton Rouge, Louisiana. She joined Esso 11 years ago as secretary to the head of the Process Engineering department. Three years later she took over her present position. So efficient has been her organization of the maze of files that other Esso refineries have patterned reorganization after her system. Other industries in Baton Rouge have sought her advice in setting up their files and

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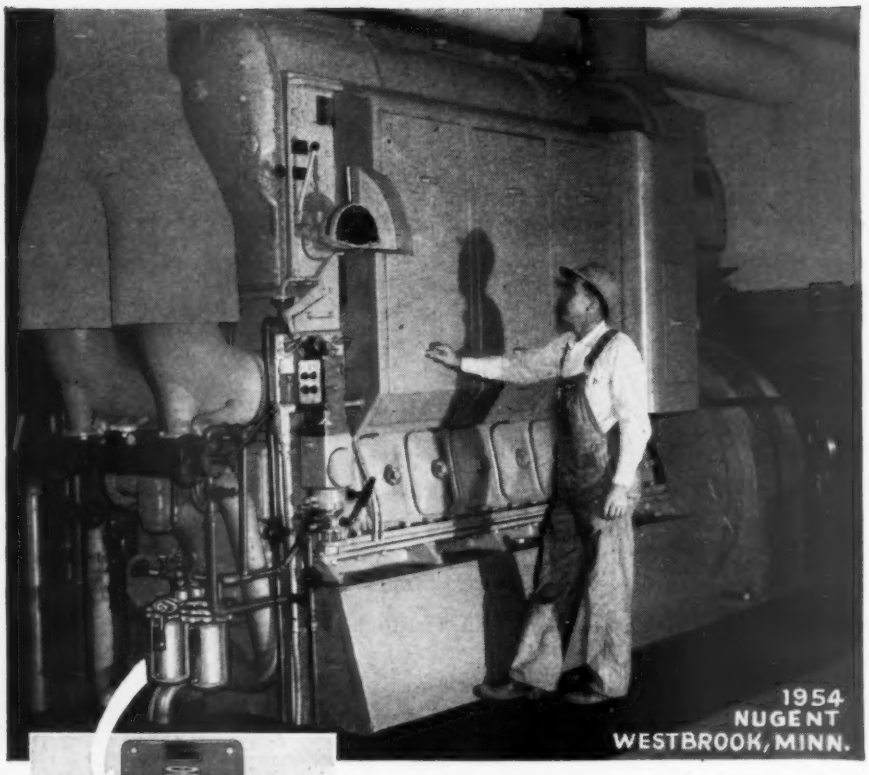

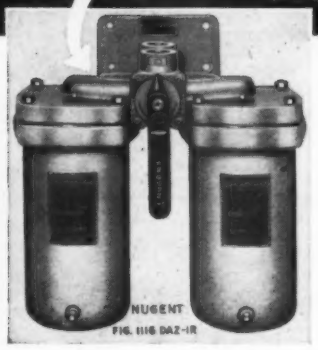

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Power Plant Diesel protected by Nugent Fuel Oil Filters

A power plant can't afford "second best" when it comes to diesel fuel oil filters. *That's why* leading diesel manufacturers install Nugent Fuel Oil Filters on nearly every engine slated for power plant service. *That's why* a Nugent Duplex Fuel Oil Filter was included as original equipment on the 960 HP Fairbanks Morse recently installed for municipal power service at Westbrook, Minnesota.

Nugent Duplex Fuel Oil Filters of this type utilize an inexpensive bag type cartridge that actually removes 99.8% of all solid foreign material from the fuel oil. The cartridge lasts a long time, is easy to replace and presents 20 times more filtering area than any other charge of comparable size. The filter covers, valve manifold and bracket is one casting. Units can be operated separately or in parallel and slow manipulation of the valves will not cause stoppage or high pressure.

You, too, can't afford "second best" when it comes to fuel or lube oil filtering. So, take a tip from leading diesel manufacturers and investigate the possibilities of Nugent Filtering units for your own equipment.

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Women at Work

Louisiana State University annually sends its commerce students to the refinery to study the system before they receive their degrees.

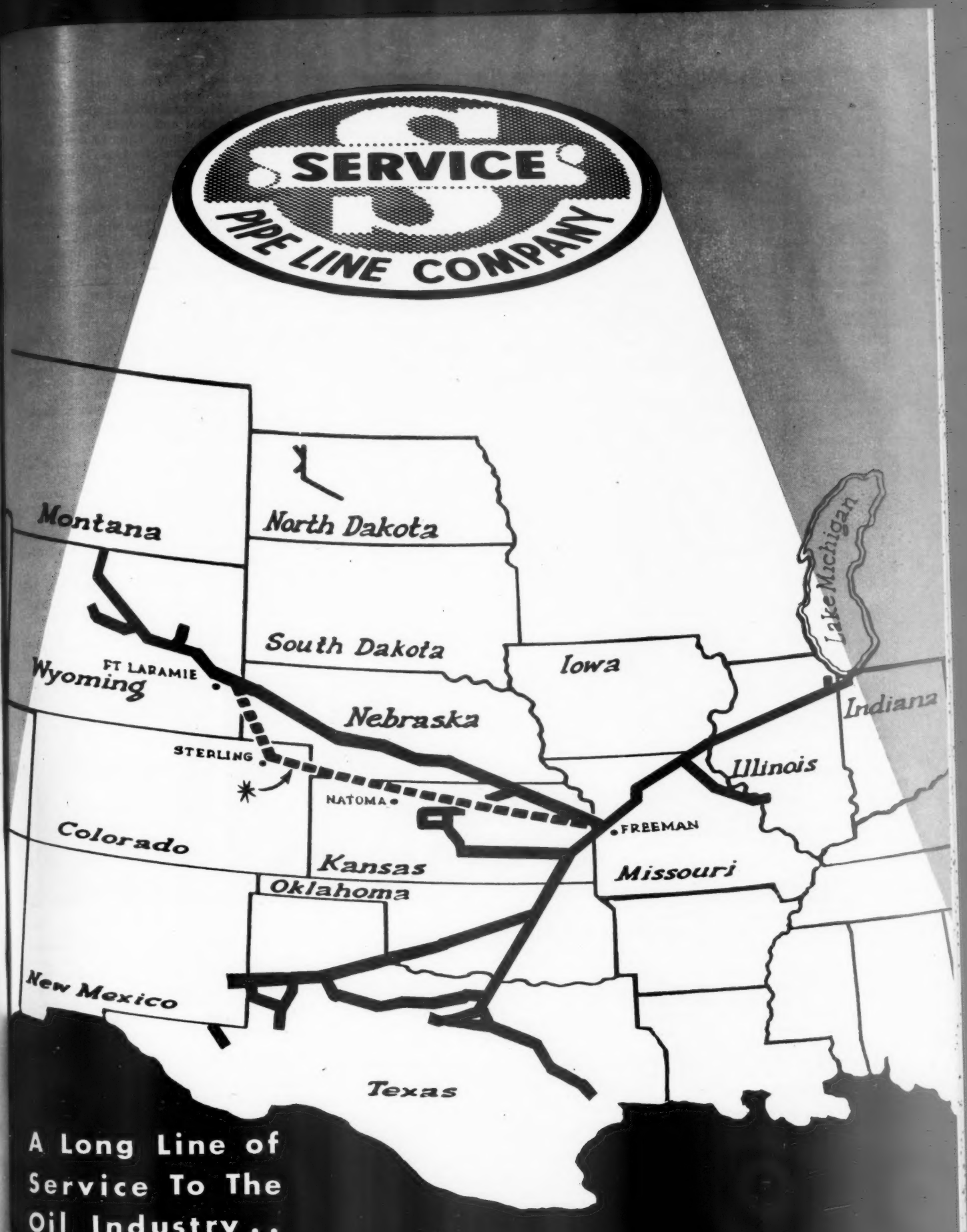
Lucille brought an interesting background career to her present job. She went to work in Louisiana's Capital City in the Constitutional Convention of 1921, and subsequently did secretarial work for eight of Louisiana's governors. In 1929, she married and went to New York where she worked as a secretary in the National City Bank and the Bank of Manhattan.

After her daughter, Lynn, was born in 1932, she worked for Mayor O'Brien to survey Manhattan's City government. She also worked for the Internal Revenue Department, Station WOR, and the New York Ordnance Department. She returned to Louisiana in September 1942, at which time she joined Esso. Lynn has followed in her mother's steps and is now a secretary, too. She is employed in the Law Department at Esso.

Lucille's mother, Mrs. Roger Bourgeois, lives with her and Lynn in a cute new house near the University.

Lucille, her daughter, and her mother are active in gardening and general "fixing up" the place. They are members of St. James Episcopal Church. Her favorite pastime is fishing, but the new home doesn't allow too much time for that any more.

Lucille Dutton with her improved filing system.



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PERSONALS

▸ **J. C. Lovelady** has been named manager of the employee relations department of The Carter Oil Company. **Frank Gaines, Jr.,** succeeds Lovelady as assistant manager.

Lovelady, is a graduate of Oklahoma A and M College with a BS in engineering. He was first employed by Carter as a roustabout in Burbank field. He was named assistant manager of the department in 1950. Gaines, a graduate of Michigan State College with a BS in chemical engineering, joined Carter at Seminole, Oklahoma. Gaines was with Creole Petroleum Corporation at Caracas, Venezuela when he returned to Carter in 1953.

▸ **Joseph A. Thomas** has been elected a member of the board of directors of Tide Water Associated Oil Company. Thomas, a graduate of Yale University and Harvard Business School, is a partner of Lehman Brothers, investment bankers, New York. He replaces John Hertz, a senior partner of Lehman Brothers.

Russel D. Richardson has been appointed controller of Tide Water. Richardson joined Tide Water at its Avon, California, refinery in 1921. He was formerly regional controller of the company's western division.

▸ **Marshall J. Kimball** has been promoted to gas engineer, heading the gas section of The California Public Utilities Commission. He is a Stanford University graduate who began work for the Commission in 1937. He has been head of the valuation section. **Clarence Unnevehr,** senior utilities engineer in the valuation section, was promoted to valuation engineer, replacing Kimball. Unnevehr, a University of California graduate, has been a Commission employee since 1946. **John J. Doran,** senior utilities engineer in the research section, was promoted to electrical engineer, in charge of the electric section. He is a University of Santa Clara graduate who has been with the Commission since 1947.

▸ **Ross McCollum** has been elected president of Mascot Oil Company to replace the late **Lloyd Williamson.** McCollum is also president of National Oil Company and vice president of Basin Oil Company.

▸ **Robert W. Breed** has been appointed senior district representative for the New England office of the Oil Industry Information Committee of the American Petroleum Institute. Breed was formerly assistant manager of the Convention and Visitors Bureau of the Greater Boston Chamber of Commerce. He succeeds **Jacques Ellison,** who resigned.

▸ **Professor Harold O. Bolz** has been named new Associate Dean of the College of Engineering of The Ohio State University. Bolz has been a member of the Purdue University faculty since 1938. He is a graduate of Case Institute of Technology and has a BS and a MS in mechanical engineering.

▸ **Winston J. Woellert** has been promoted to assistant director of Continental Oil Company's employee benefits division. Woellert succeeds **L. E. Barrett** who has been promoted to director of employee benefits. A graduate of the University of Texas, Woellert joined Conoco in 1949.

▸ **Theodore Hawley** independent oil producer of Conrad, Montana, has been named a member of the Montana Oil and Gas Conservation Commission. Hawley replaces **T. R. Barnes** who was transferred to California.

▸ **Herbert Hoover, Jr.,** has resigned from Union Oil Company's board of directors. Hoover had been board chairman of United Geophysical Company which was recently sold by Union.

▸ **W. O. Narry,** traffic manager of the Richfield Oil Corporation, has been re-elected president of the California chapter of American Society of Traffic and Transportation.

▸ **H.E. Treichler, Jr.,** has been promoted to the position of assistant to the president of the Houston Oil Company of Texas. A graduate of the Colorado School of Mines, Treichler was associated with The Texas Company in its field operations until he joined the Houston Oil Company of Texas in 1950. He is being succeeded as general superintendent of drilling and production for the company by **Barrett E. Booth,** formerly superintendent of the company's southwestern district at Beeville, Texas.

▸ **W. F. Crooks** has been promoted to vice president and treasurer of General Exploration Company. **R. S. Ballantyne, Jr.,** was named vice president and **H. R. Sharpless, Jr.,** was promoted to assistant secretary. Crooks was formerly treasurer and assistant secretary and Ballantyne was a petroleum engineer.

▸ **Raymond E. Thomas** has been transferred to Sohio Petroleum Company's Billings, Montana, office as division supervisor of rental and records. Prior to employment by Sohio, Thomas worked as a scout for the Lone Star Gas Company. He joined Sohio as a scout, working out of Abilene, Texas.

▸ **W. R. Huber,** general manager of public relations for Gulf Oil Corporation, has been elected chairman of the National Oil Industry Information Committee for 1955. Huber will take office in December, succeeding **G. Stewart Brown,** manager of public relations for Standard Oil Company of California.

The following vice chairmen were elected: **J. H. Sembower,** Shell Oil Company; **Roy M. Stephens,** Humble Oil and Refining Company; **L. R. Kamperman,** Leonard Refineries; **Kerryn King,** The Texas Company, and **Richard Rollins,** Atlantic Refining Company. **John S. Cooke** of the American Petroleum Institute was reelected secretary.

▸ **Hayden Hughes** has been appointed assistant to the vice president for production of the Mid-Continent Petroleum Corporation. Hughes was assistant general manager of International Petroleum, Ltd., in charge of production, exploration, and refining in Bogota, Columbia. He is a graduate of the University of Oklahoma.

▸ **George M. Cunningham,** president of American Overseas Petroleum, Ltd., exploration affiliate of the California Texas Oil Company, is visiting Australia in connection with oil drilling operations by firms connected with Caltex.

D. J. Smith

L. W. Moore

L. A. Castler

▸ **D. J. Smith** has been elected president of The American Oil Company following reorganization of American and its affiliated companies. Smith has served in executive capacities with Standard of Indiana and associated companies. He was president of Pan American Petroleum and Transport Company at the time of the reorganization.

L. W. Moore has been elected executive vice president of American. Moore, a graduate of M.I.T., joined American's parent company in 1933. He was first vice president of the Pan American Petroleum and Transport Company until the reorganization.

▸ **Floyd L. Drake** has been appointed general credit manager for Socony-Vacuum Oil Company, Inc. He succeeds **William M. Watson.** Drake became assistant general credit manager 15 years ago.

▸ **E. J. McClanahan** has been appointed vice president and director of western operations of Standard Oil Company of California. McClanahan will have responsibility for operations of the company in the seven western states, Alaska, and Hawaii.

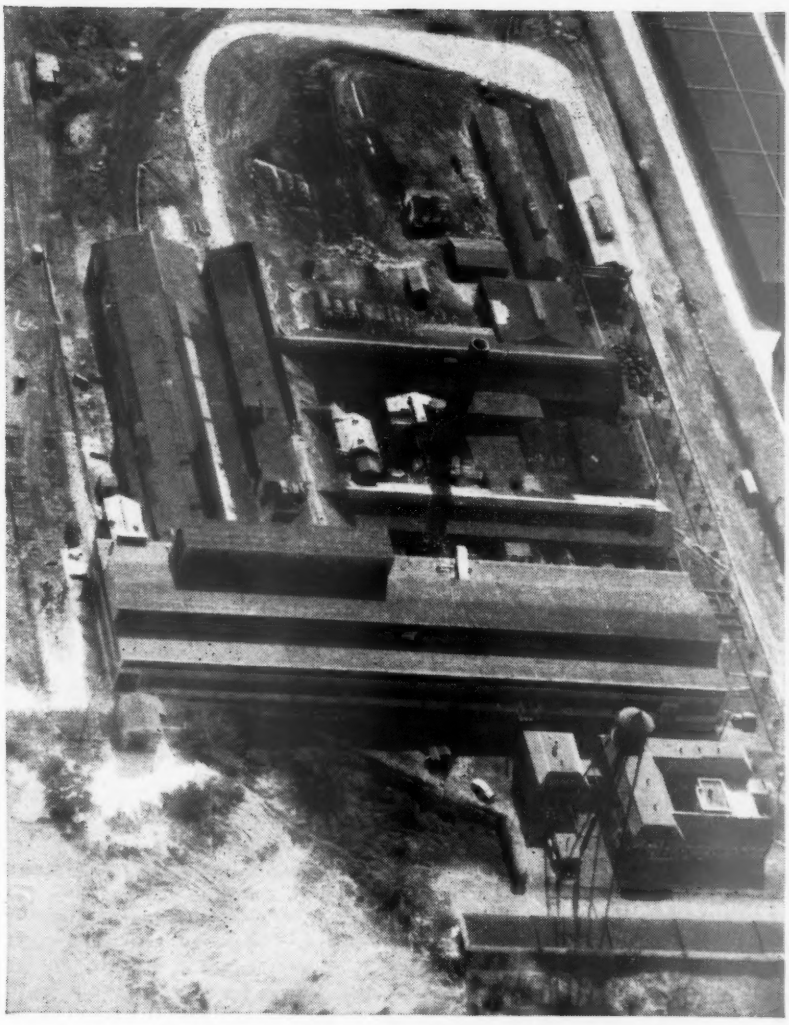
▸ **Leo A. Castler** has been advanced to the post of chief design engineer in the engineering department of the General Petroleum Corporation. Castler joined the company in 1943 as a senior draftsman. He is a graduate of the University of California.

▸ **John R. Donnell** has been named vice president in charge of supply and transportation for Ohio Oil Company. He succeeds **O. F. "Mike" Moore.**

▸ **Dr. Irl C. Schoonover** has been appointed chief of the Mineral Products Division of the National Bureau of Standards. Schoonover, formerly assistant chief of the Organic and Fibrous Materials Division and chief of the Polymer Structure Section, succeeds **Dr. Herbert Insley** who retired in January 1954.

William D. Appel was appointed assistant chief of the Organic and Fibrous Materials Division and **Dr. Norman Bekkedahl** chief of Polymer Structure Section to succeed Schoonover. Appel is chief of the Textile Section and Bekkedahl has served for many years as a chemist in the Rubber Section.

New GRAVER Edge Moor Plant

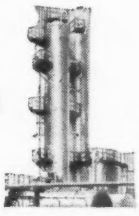


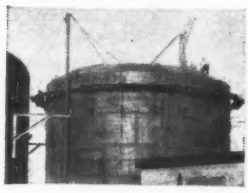
...occupying 25 acres

at Edge Moor, Delaware

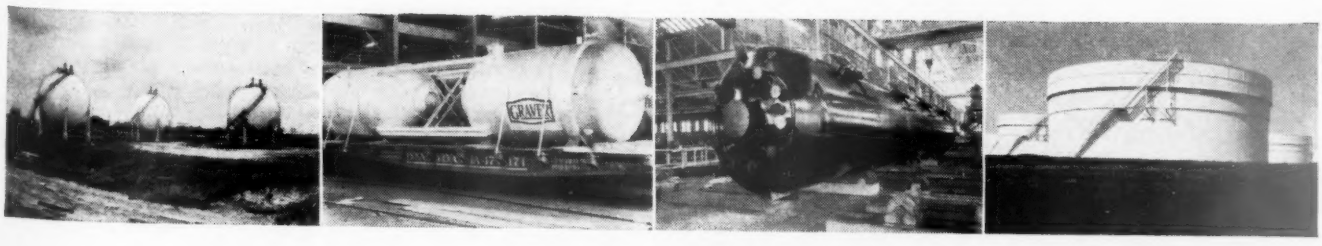
(adjacent to Wilmington)

for the manufacture

of towers  pressure vessels

...eastern headquarters for  field-erected tankage

and exclusive GRAVER conservation designs



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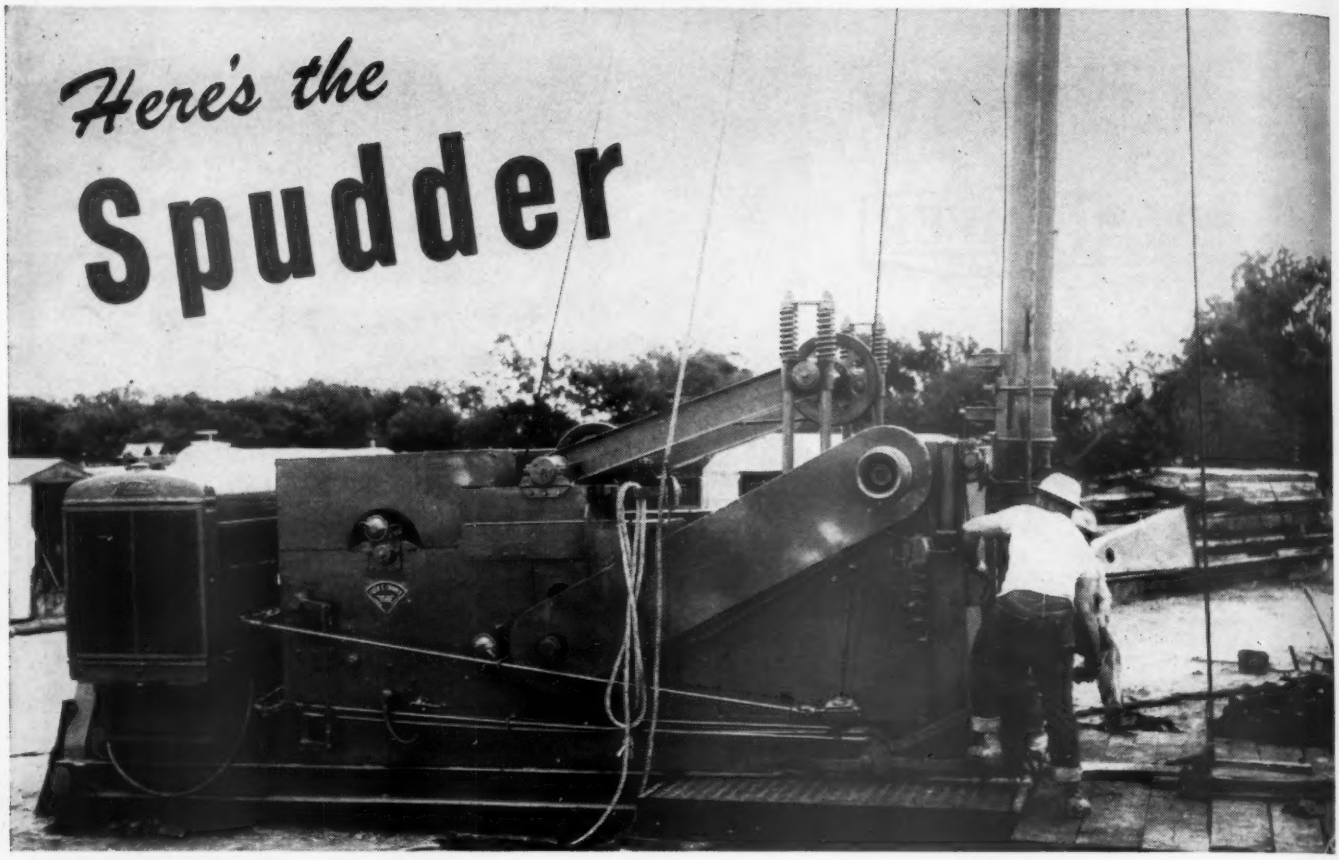
LOS ANGELES • FONTANA, CALIF. • SAN FRANCISCO

GRAVER ...tank fabricators for 97 years



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POWER for fast bailing, swabbing and rod and tubing work.
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BIG BRAKES that handle the load safely.
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EASY to service—most bearings are pre-lubricated and sealed and require no attention—other points of lubrication are easily serviced from outside the machine.

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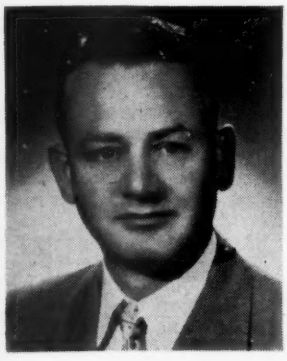
John H. (Jack) Lewis has resigned as vice president in charge of the foreign department of Drilling and Exploration Company, Inc. Lewis had been with the company about 12 years. The foreign department is being combined with the domestic contract drilling department and will be operated by **Robert L. (Bob) Rose.** Rose, with Drilling and Exploration for 11 years, has been vice president of Drilling and Exploration Company, Inc's drilling subsidiary under which all of its domestic contract drilling has been done.

Wallace W. March, vice president and assistant to the president of Drilling and Exploration, is being moved to Los Angeles where he becomes vice president and secretary and treasurer of the company's subsidiary.



M. F. Owens

Marvin F. Owens has been named a vice president of the Central Bank and Trust Company of Denver, Colorado. He will be in charge of the bank's newly formed oil and gas department. Owens was associated with the Bay Petroleum Corporation for the past 8 years as chief petroleum engineer and assistant general production superintendent. Prior to that he was connected with the British-American Oil Producing Company following his graduation from the University of Oklahoma in 1937.

Lee M. Smith has joined the staff of the Western Oil and Gas Association. Smith was assigned to the public relations department as a field representative and will assist with the association's oil information program.

Robert Milliken has been appointed superintendent of the traffic department for Royalite Oil Company, Ltd.

Richard A. Grant, vice president, general counsel, and a director of Fullerton Oil Company was reelected president of Oil Producers Agency of California at the recent annual meeting of the Agency's board of directors. **R. R. Von Hagen,** president of the Lloyd Corporation, was elected a vice president. **H. D. Campbell,** president of Franco Western Oil Company, and **W. H. Geis,** consultant, were reelected vice presidents. **S. E. Cavanaugh,** vice president of Pacific Western Oil Corporation, was elected secretary-treasurer and **Verne Harrell,** vice president of Bankline Oil Company, was reelected assistant secretary-treasurer. **Stark Fox,** executive vice president of the Agency was also reelected.

Charles D. Signorelli has been promoted to divisional controller of the western division of Tide Water Associated Oil Company. He was also appointed a member of the company's operating committee.

Joseph A. Winger, manager of The Texas Company's 15-state central sales territory, has been named manager of operations of the domestic sales department. Winger succeeds **H. W. Holland,** who has been appointed assistant general manager, terminals. **James M. Doss,** assistant manager of the central territory, has been named to succeed Winger as territorial manager.

Winger has been associated with The Texas Company and affiliated companies since 1922, and since 1951, has been manager of the company's central sales territory. Doss has been assistant manager of the central territory since 1951. He attended Northeast Oklahoma A and M College and began his Texas Company service as an assistant service station sales agent in 1925 in Miami, Oklahoma.

Russell S. McFarland, Seaboard Oil Company, has been appointed to the National Petroleum Council, succeeding **John M. Lovejoy,** who has retired.

L. F. McCollum, president of Continental Oil Company, has been named chairman of a committee to study and report on the petroleum productive capacity of the U. S.

William L. Fanning, Jr., has been appointed divisional supervisor of the crude and products section of Tide Water Associated Oil Company's eastern division. He succeeds **Harold F. Parsons** who retired after 37 years of service with the company. J. H. Brown has been assigned the general administrative duties formerly handled by Parsons in connection with the operations of The Tide-Water Pipe Company, Ltd., and the Bradford Transit Company.

Marshall Kay, Columbia University, and **G. M. Knebel,** Standard of New Jersey are candidates of the presidency of the American Association of Petroleum Geologists during 1955-56.

Other officer nominees are: For vice president, **Horace D. Thomas,** University of Wyoming, and **Henry N. Toler,** consultant, Jackson, Mississippi; for secretary-treasurer, **Frank Gouin,** independent oil producer, Duncan, Oklahoma, and **W. A. Waldschmidt,** consultant, Midland, Texas; for editor, **W. C. Krumbein,** Northwestern University, and **Grover E. Murray,** Louisiana State University.

Charles W. Guy has been appointed vice president of Texas Natural Gasoline Corporation. Guy joined the Louisiana Department of Revenue as a field auditor upon his graduation from Louisiana State University in 1936. In 1939 he joined General Gas Corporation as auditor. He was elected vice president in 1942 and executive vice president in 1950.

Guy is a member of the board of directors of the LPGA and past president of the Butane-Propane Institute of Louisiana.

Thomas S. Atkinson has been elected a vice president of Douglas Oil Company and will head the company's new department of exploration and production. Atkinson will direct the company's activities in California and Peru from Los Angeles, California.

T. S. Gay has been elected to the board of Phillips Petroleum Company. He succeeds **Eugene E. Dupont** who retired after 35 years as a board member. Gay is head of Phillips' New York office.

Conrad J. Bauer, head of Standard of New Jersey's foreign petroleum economics section, has been named assistant director of the Oil and Gas Division of the Department of Interior.

Dr. Robert C. Gunness has been appointed general manager of a new supply and transportation department of Standard Oil of Indiana. **J. W. Boatwright** has been named assistant general manager of distribution economics. **D. S. Warning** was appointed manager of the distribution economics department.

R. E. Nelson, Jr., was named assistant general manager of operations. **S. L. Jackson** was named manager of the products pipe line department, and **D. V. Hartzell,** manager, marine department.

Louis G. James has been elected comptroller for the Lone Star Gas Company and its wholly owned subsidiary, the Lone Star Producing Company. James, assistant comptroller for more than two years, succeeds **L. L. Dyer,** who retired August 31. **H. J. Yonkers** and **W. R. Payne** were elected assistant comptrollers. Yonkers advances from manager of the auditing and statistical division and Payne from manager of the general accounting division of the comptroller's department.

James began his Lone Star career in 1923 as clerk in the chart department and in 1926 was transferred to Bonham, Texas, as cashier and bookkeeper. He became assistant comptroller April 15, 1952. Yonkers joined Lone Star in 1930 as a traveling auditor and in 1941 he was appointed chief clerk in the auditing department. Yonkers was appointed chief statistician in 1952 and manager of the auditing and statistical department in September, 1953. Payne first worked for Lone Star in 1922 as an accounting clerk. He left the company a year later and returned in August, 1925. He returned to Lone Star to assume the duties of assistant chief clerk in the accounting department. In 1953 Payne was appointed manager of the general accounting division.

Martin F. Casey has been elected executive vice president of Forest Oil Corporation. Casey, with Forest since 1938, has been vice president in charge of exploration for the southwest division.

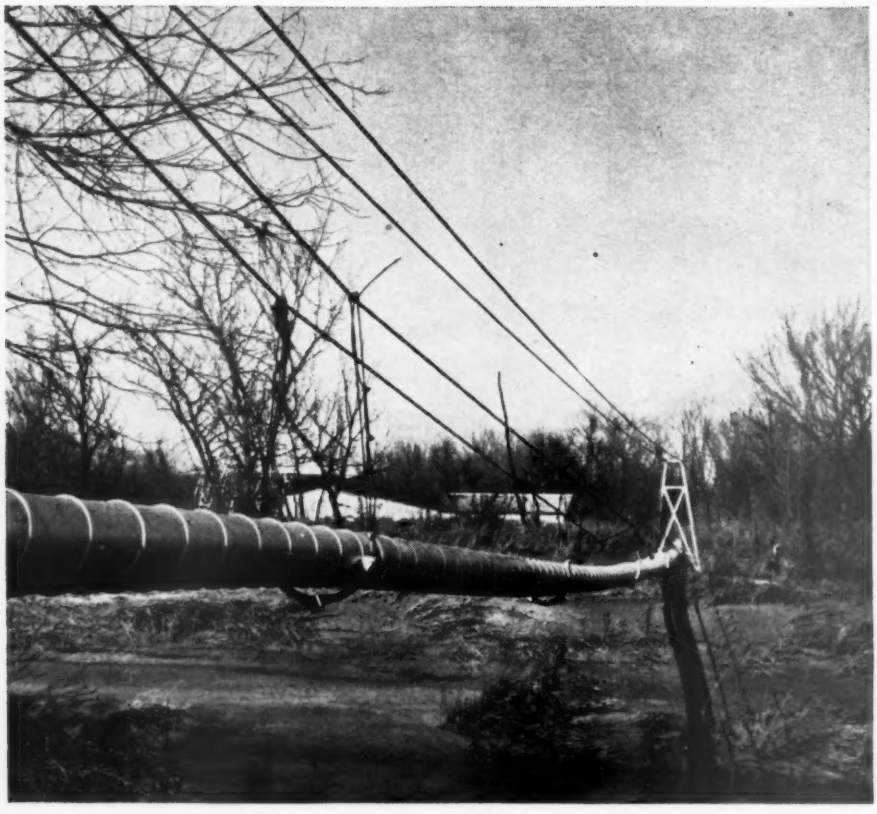
Robert E. Porter has been promoted to the newly-created position of chief pilot for Shell Oil Company. Porter will coordinate the operations of aircraft employed by Shell and its affiliates throughout the United States and Canada. Porter joined Shell in 1952 as a pilot for its exploration and production department in Casper, Wyoming. He was transferred to New York last March.

Porter was formerly an airline captain and superintendent of maintenance for Midwest Airline in Omaha, Nebaska. Before joining Midwest he owned and operated a Shell service station in Los Angeles, California. He is a veteran of World War II.

P. H. Holt has been put in charge of Standard Oil Development Company's patent licensing activities. Holt was previously an assistant director of the Esso Laboratories Research Division. A graduate of M.I.T., he joined the company in 1937. **Dr. Leonard E. Carlsmith** will be responsible for technical advice and contacts with licensees, contractors, and engineering units of the company. Carlsmith received his BS degree from Stanford University, his master's from M.I.T., and his doctorate from Columbia University. He joined the company in 1935.

XUM

NO STRANGER HERE



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DEATHS

Max W. Ball, senior member of the firm of Ball Associates, Washington, District of Columbia, died unexpectedly at Doctors Hospital, August 28. He had been active at his office until the evening before his death. Ball was internationally known as an expert on petroleum matters and had made significant contributions to the development of the petroleum industry worldwide. Among the honors which had been accorded to Ball were the following: Medal of Merit for distinguished achievement, Colorado School of Mines; Gold Medal of the Department of Interior for distinguished service, and Freedoms Foundation Gold Medal for contributions to the American way of life.

During World War II Ball served as special assistant to the Deputy Administrator of the Petroleum Administration for War and later on was made director of the Oil and Gas Division of the Department of Interior. At the time of his death Ball was a member of the National Petroleum Council and had served as chairman or vice chairman of important committees of that organization. He was a past president of the American Association of Petroleum Geologists, which he had helped organize, and was a member of a number of other professional societies in which he had served prominently. Ball was also primary consultant to the government of Israel and Turkey in the preparation of the recently enacted petroleum laws of those countries.

Noble A. Endicott, a vice president of The Continental Supply Company in charge of Gulf Coast operations, died at his home in Houston, Texas, on September 4. Endicott had been associated with Continental for the past 38 years. He had served in various capacities with the company during that time. Endicott's most recent previous position was manager of Continental's Canadian operations.

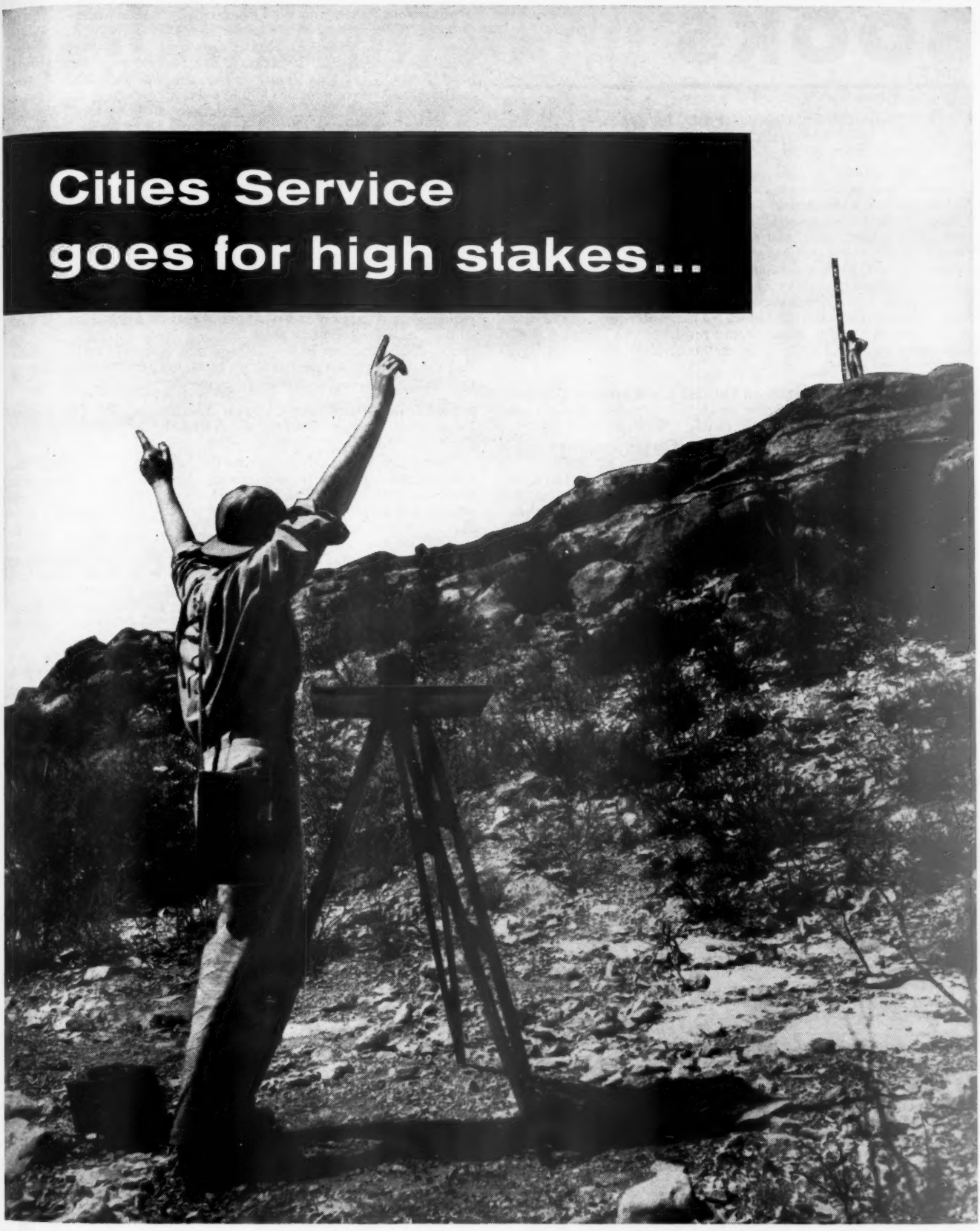
Emmor Jerome Miley, a pioneer in oil development in California, died August 29, 1954. Miley was a prominent figure in the early development of such fields as Huntington Beach, Signal Hill, Ventura Avenue and Bakersville Front.

Martin C. Madsen, chief engineer for Northern Natural Gas Company died suddenly September 4, in Omaha, Nebraska. Prior to joining Northern he was with Continental Construction Corporation (now Natural Gas Pipeline Company of America) where he was in charge of design and construction of all compressor stations on the original pipe line system between Fritch, Texas, and Chicago, Illinois. Madsen was formerly chief draftsman for Empire Companies.

John P. Buwalda of the California Institute of Technology died on a geological field trip in Frazier Mountain Park, Ventura County. Dr. Buwalda came to Caltech in 1926 to organize the Division of the Geological Sciences. As chairman of the division, he assembled the staff and organized instruction and research in three main fields, geology, paleontology, and geophysics (including seismology). He retired as division chairman in 1947 in order to devote more time to research in structural geology.

Jacob Emery Wyatt, president of Chanute Refining Company and Consolidated Fuel Oil Company, Inc., died recently at his home in Kansas City.

Cities Service goes for high stakes...



Test wells are put down on an average of one every 4 days by

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BOOKS ★

ASTM Standards On Gaseous Fuels, *Published by American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Price, $2.50. Pages, 184.*

The 1954 edition of this compilation of ASTM Standards on Gaseous Fuels contains in their latest approved form all of the ASTM test methods used in this field.

The test methods cover: Measurement of gaseous fuel samples; sampling (natural gas; manufactured gas; liquefied petroleum gases); analysis of (natural gases by the volumetric-chemical method; natural gases and related types of gaseous mixtures by the mass spectrometer; carbureted water gas by the mass spectrometer); gaseous fuels (water vapor content, by measurement of dew-point temperature; calorific value, by the water-flow calorimeter; specific gravity); sulfur in petroleum products and liquefied petroleum gases by the CO_2-O_2 lamp method; vapor presure of liquefied petroleum gases.

The Fifth Annual Institute on Oil and Gas Law and Taxation, *Southwestern Legal Foundation of Dallas, Matthew Bender and Company, Albany 1, New York. Pages, 658. Price, $18.50.*

Addresses of 15 key figures and advisers to the petroleum industry prepared for and delivered at the 5th annual Institute on Oil and Gas Law and Taxation form the basis for this book. The meeting was attended by 300 operating, legal, tax and accounting experts for the purpose of hearing about the solutions, methods and techniques that are currently being adopted for dealing with legal and tax problems in the oil and gas field.

The topics covered include: "Equitable Relief from Termination of Leases for Failure to Meet Requirements of the Drilling and Delay Rental Clauses," "Assignments of Interest in Oil and Gas Leases, Farm-out Agreements, Bottom Hole Letters, Reservation of Overrides and Oil Payments," "Division Orders," "Effect of Conservation Laws, Rules and Regulations on Rights of Lessors, Lessees and Owners of Unleased Mineral Interests," "What to Do About Problems Incident to Joint Ownership of the Oil and Gas Leasehold Estate," "What to Do About Problems Incident to the Marketing of Gas," "Some Aspects of Financing Oil and Gas Transactions," "Oil and Gas Financing," "Maintaining the Lease in Effect Other Than by Payment of Delay Rentals and Shut-in Royalties," "Taxation of Oil and Gas Interests Received in Payment for Property or Services," "The Investors Group: How to Set Up an Oil and Gas Venture From the Tax Standpoint," "How to Handle Tax Problems of Oil and Gas Operations in Latin America and the Middle East," "Delay Rentals, Bonuses and Minimum Royalties," "Excess Profits Tax Problems Particularly Related to the Oil and Gas Industry," and "Recent Developments in the Taxation of Oil and Gas Interests."

Geographical Essays, *William Morris Davis, reissued by Dover Publications, Inc., 1780 Broadway, New York 19, New York. Price, $5.50. Pages, 783.*

William Morris Davis, the teacher-geologist who first described the geographical cycle, was also a brilliant field researcher, according to the evidence of his famous book, "Geographical Essays" which has been reissued in an unabridged edition.

Known as the author of the so-called American System, Davis gathered field data on every continent except Antarctica. He made studies of Pennsylvania river valleys, New England river terraces, glacial erosion in Switzerland and Norway, and the mountain ranges of the Great Basin, all of which are still used today by geologists, petrologists, mining engineers, and geographers.

Petroleum Microbiology, *Ernest Beerstecher, Jr., The Elsevier Press, 402 Lovett Boulevard, Houston, Texas. Pages, 375. Price, $8.00.*

Ernest Beerstecher, Jr., is a scientist who can write. By selecting a subject on which he is an authority (he is associate professor of biochemistry at the University of Houston, Houston, Texes) and picturing it in a thoroughly readable style, he has written a book that is colorful as well as factual.

"One of the most difficult infants of the oil industry," says author Beerstecher, "has resulted from the marriage of petroleum engineering and bacteriology. New and strange terms have been invented which clothes the child and confuse the parents."

Divided into three parts — Exploration, Production, and Manufacturing — the book has eleven chapters treating such subjects as "The Use of Microorganisms in Petroleum Explorations," "The Activities of Microorganisms in Petroliferous Formations," and "Petroleum and Its Products as Sources of Infectious Microorganisms." It contains numerous illustrations, tables and historical and scientific references.

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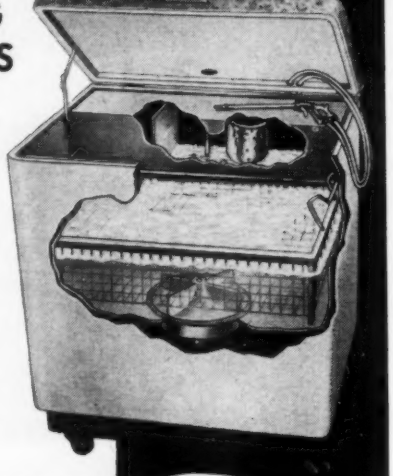

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JOSEPH F. DUDDY, MANAGER

LAUGH with BARNEY

"What's eating you?"

"Oh, nothing much, but when your girl friend said she'd dig up a date for me—brother, she wasn't kidding!"

The president of the company was showing a friend through his offices.

They went past a series of small private rooms in which young men were busily hammering away at typewriters.

"These are some of our junior executives," said the president.

"But they're typing letters," said his friend.

"Sure," replied the president, "I can get junior executives today for half the price I have to pay stenographers!"

The lady of the house summoned a TV serviceman to fix the set. Spreading out his tools, the repairman inquired, "What seems to be the trouble?"

Replied the little woman, "Well for one thing, all the programs are lousy!"

Visiting a dance at a school for the deaf and dumb a young man was fascinated as the speechless couples danced and gesticulated. An interpreter carefully explained what their fingers were saying. Suddenly the young man noticed two fellows over in the corner. One had his hand under his coat, moving his fingers wildly.

"What's he doing?" came the inquiry.

"Oh, him," was the explanation, he's telling dirty stories!"

A man is never so weak as when some woman is telling him how strong he is.

Sign under clock in a Colorado town: "This clock will never be stolen—our employees are always watching it."

A business man was interviewing his daughter's suitor. "I regret I cannot see my way to allow you to marry my daughter at present," he said, "but give me your name and address and if nothing better turns up in the near future, you may hear from me again."

A gentle old lady on a suburban tram watched for some time, with the kindliest interest, a young soldier sitting next to her. The fellow was chewing gum vigorously. Finally, she leaned across and patted him on the knee and said, "I'm awfully sorry, but it simply isn't any use trying to talk to me, young man, I'm completely deaf!"

Poise: The art of raising the eyebrows instead of the roof.

Two business men were talking in the club car of a streamliner speeding across the country and in the course of their conversation they became extremely critical of the young men of today.

"Look at them," said one, "and see how reluctant they are to marry and settle down."

"That's right," agreed the other.

"They seem to fear marriage," said the first. "Why, before I was married, I didn't know the meaning of fear."

A man from Scotland was traveling through the Holy Land on a vacation trip and he came to the Sea of Galilee. Inquiring the price of a pleasure boat to see the sights he found that they were four dollars an hour.

"Four dollars an hour?" he exclaimed. "Why, I can rent a boat in Aberdeen for less than half as much."

"Ah! But this is Palestine," replied the boatman, "and these are the waters on which our Lord walked."

"Nae wonder He walked," replied the Scotsman in disgust.

The only time a woman won't argue about getting so little for her money is when she's buying a strapless evening gown.

Mother sought to effect an improvement in the department of the children by offering a reward each Saturday for the most obedient of the family during the week.

"Shucks! That's not fair," young Oscar complained. "Daddy will win every time!"

The salesman's knock was answered by something beautiful.

"Oh, good morning, madam. May I speak to your husband?"

"Sorry, he's away on business, and won't be back for a week."

He took another long look, sighed, and asked: "May I come in and wait?"

While watching a fellow motorist trying inexpertly to park his car, practically every automobile driver feels impatient or experiences a burning desire to be of verbal help. A Milwaukee man who recently spotted a young woman backing in and out of a tiny parking space belonged definitely to this latter group. Ten minutes later, thanks to his directions, the car was neatly parked in the space.

"Thank you very much," said the young lady. "It was kind of you."

"I was glad to do it," said our hero.

"But," continued the young lady wistfully, "I was trying to get out."

Give some women enough rope and they will rig up a clothes line in the bathroom.

A man returned to his office one Monday morning showing the signs of a very strenuous weekend. One of his good friends sauntered over after seeing his friend sitting at his desk with his head buried in his arms.

"How did you spend the weekend?" asked the friend.

"Fishing through the ice," was the sad reply.

"Fishing through the ice? For what?"

"Cherries!" was the answer.

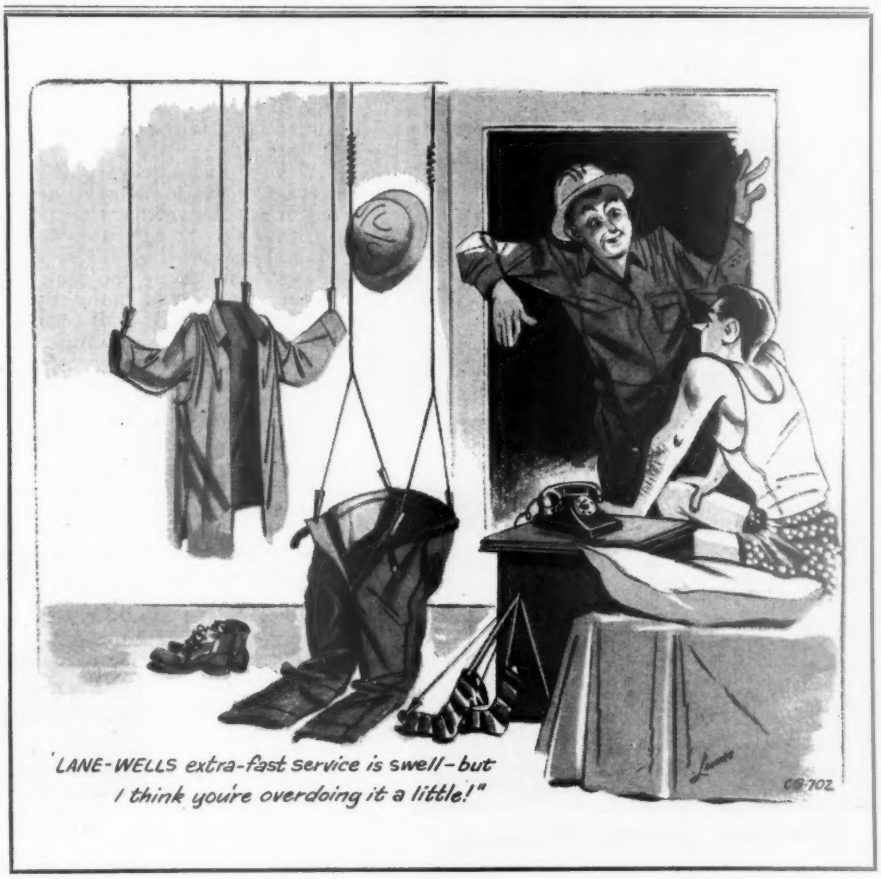
"Good morning," said a stranger to a woman who had answered the door bell. "Would you like to buy some insect powder?"

"No," she snapped. "I have no use for that stuff."

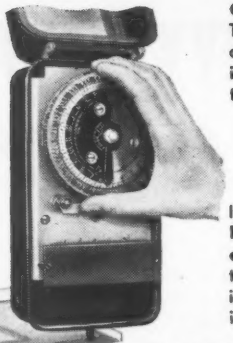
"Good," replied the stranger. "I will take that room you are advertising."

Patient: Doc, what I need is something to pep me up. Something to put me in a fighting mood. Did you put anything like that in my prescription?

Doc: No, you will find that in my bill.

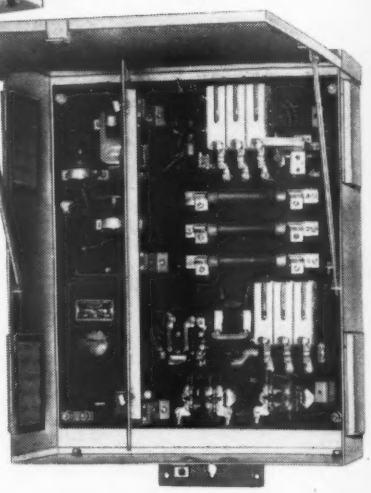


NEW CUTLER-HAMMER OIL WELL PUMPING CONTROL



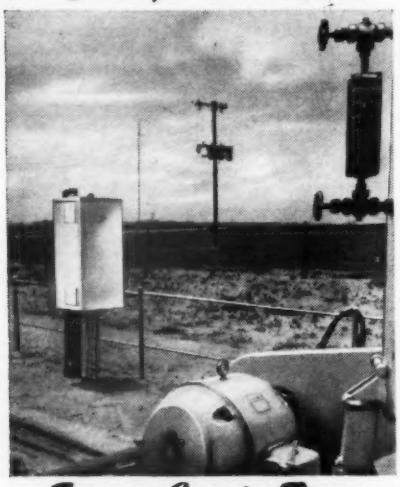
Cutler-Hammer Program Time Switch for scheduling of pumping cycle automatically. Day-omission feature available.

Improved C-H Oil Well Pumping Control permits easy in-the-field modification to the type of restarting desired after power interruptions.



Lea County, New Mexico

Incorporates provisions for 3 types of starting. Permits in-the-field alteration to meet changing needs.



Scurry County, Texas

Matrona County, Wyoming

The *improved* Cutler-Hammer Oil Well Pumping Control is now ready. It provides the same important features which have made Cutler-Hammer Oil Well Pumping Control so widely preferred in the past. But in addition, it now permits easy *in-the-field* modification of each unit to include further operating features frequently desired.

Some oil well operations require a control that restarts a pump motor automatically after a power outage. Other operations make control equipped with low voltage relays desirable . . . so each pump motor is restarted manually after power is restored. Still others desire control units equipped with automatic timers to provide the same staggered restarting automatically.

The new Cutler-Hammer Oil Well Pumping Control permits the quick and easy incorporation of any of these restarting features by two changes in the basic construction of the unit. First, the panel of the control is drilled at the time of manufacture to allow easy mounting of either the low voltage relay or the automatic timer. Second, a diagram inside the cover shows all circuit arrangements with leads numbered to permit easy change of wiring. This new standardized construction does not alter the operation of the control when used WITHOUT relay or timer but does permit easy *in-the-field* incorporation of either of these features when desired.

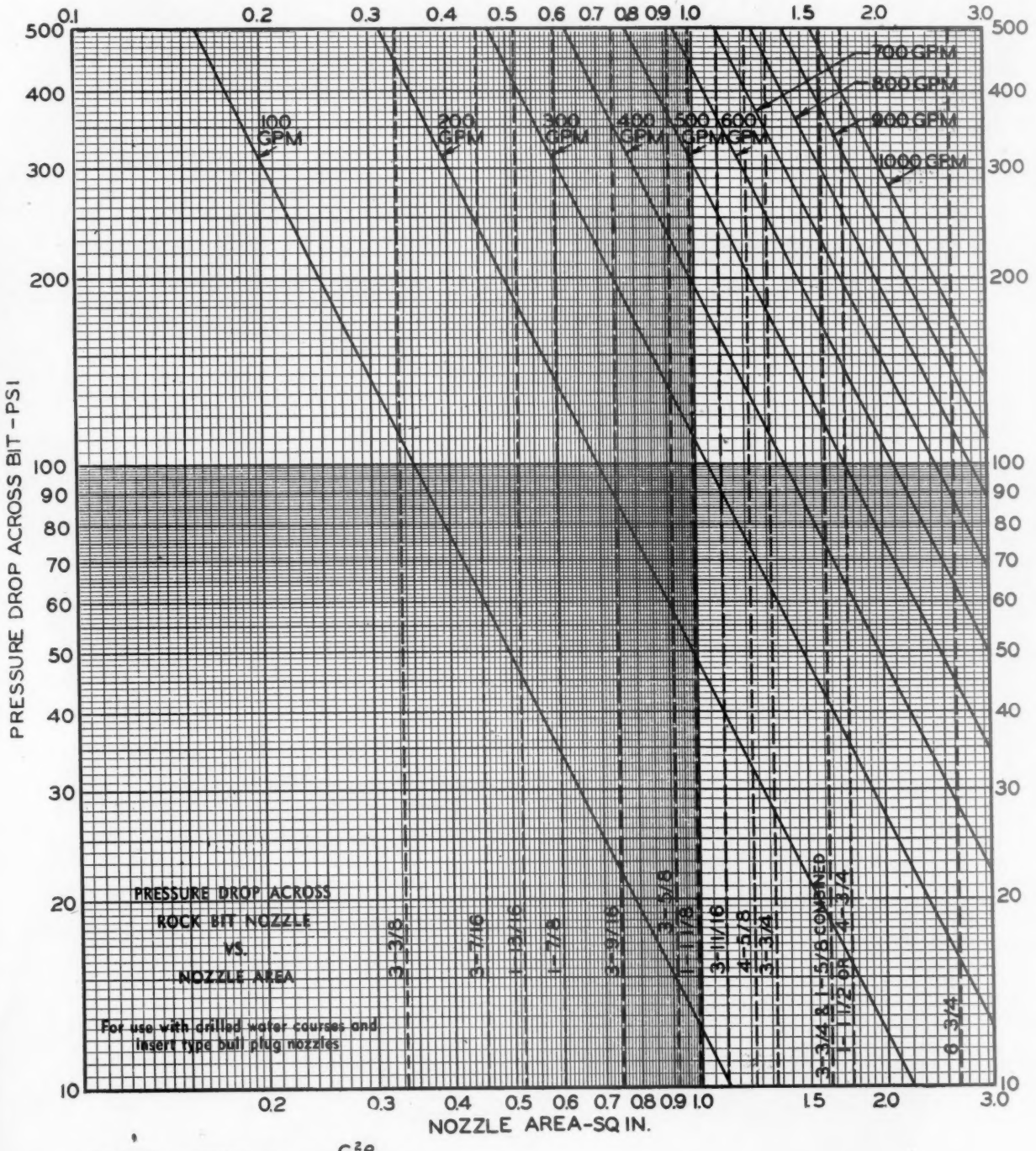
And in this control you get the following widely preferred features. Aluminized case to repel sun's heat. Chimney-draft ventilation for cooler operation. Cool, dust-safe vertical contacts. Protected openings that keep out dirt, dust and bugs. Optional 3-coil overload protection against single phasing. Flexible program time switch for scheduling and for day omission. Non-"blow up" lightning arrestors, etc., etc., etc.

Ask to see this new control now. Or write for descriptive bulletin. CUTLER-HAMMER, Inc., 459 St. Paul Ave., Milwaukee 1, Wisc. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

MEMBER AMERICAN PETROLEUM INSTITUTE

CUTLER-HAMMER
MOTOR CONTROL
C-H

DRILLING HYDRAULICS



FORMULA USED: $P = \frac{G^2 \varrho}{12031\, A^2 C^2}$

WHERE: P = PRESSURE DROP ACROSS BIT NOZZLE IN LBS. PER SQ. IN.
G = RATE OF MUD FLOW IN GALLONS PER MINUTE (GPM)
ϱ = MUD DENSITY IN LBS. PER GALLON
A = NOZZLE AREA IN SQ. INS.
C = ORIFICE COEFFICIENT

ASSUMING: ϱ = 9.5 LBS. PER GALLON
C = 0.80

Courtesy of Hughes Tool Company

HAMMOND ANNOUNCES ITS TUBESEAL* SYSTEM FOR FLOATING ROOF TANKS

new or old—riveted or welded

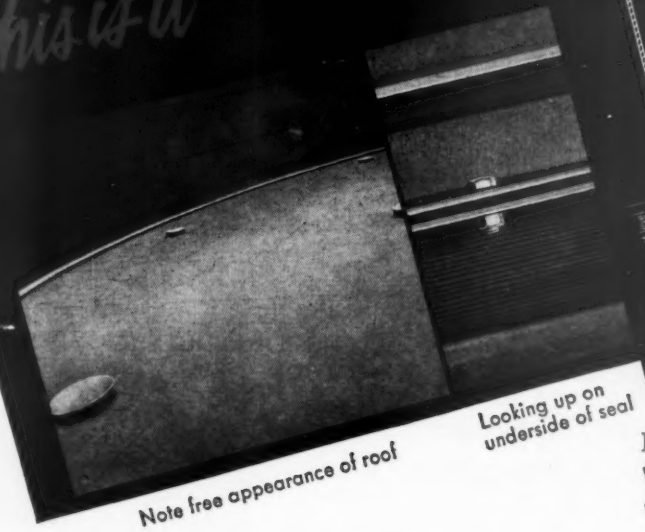
THE MOST EFFICIENT AND POSITIVE SEAL KNOWN

1. no moving parts
2. no mechanical maintenance
3. overcomes tank out-of-roundness
4. climate proof
5. non-corrodible
6. can operate to bottom of tank or above the top
7. no vapor space below the seal
8. entire circumference has tight seal under pressure at all times

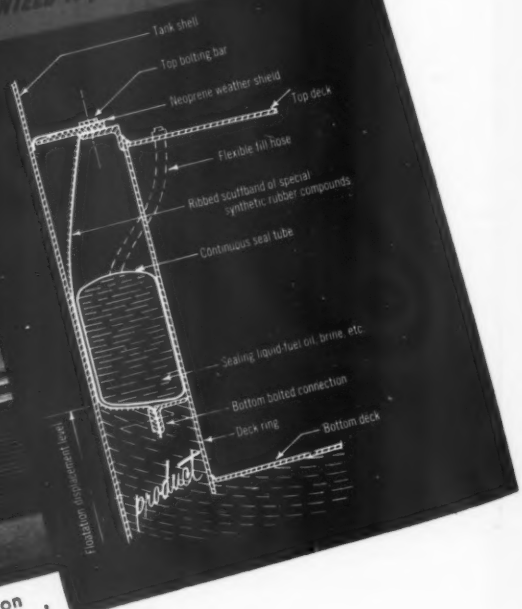
Conceived years ago but only made possible by combining HAMMOND ENGINEERING and MODERN MATERIALS

Thoroughly TESTED in commercial installation · GUARANTEED to your satisfaction

this is it*



Note free appearance of roof



Looking up on underside of seal

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ask for Bulletin TS

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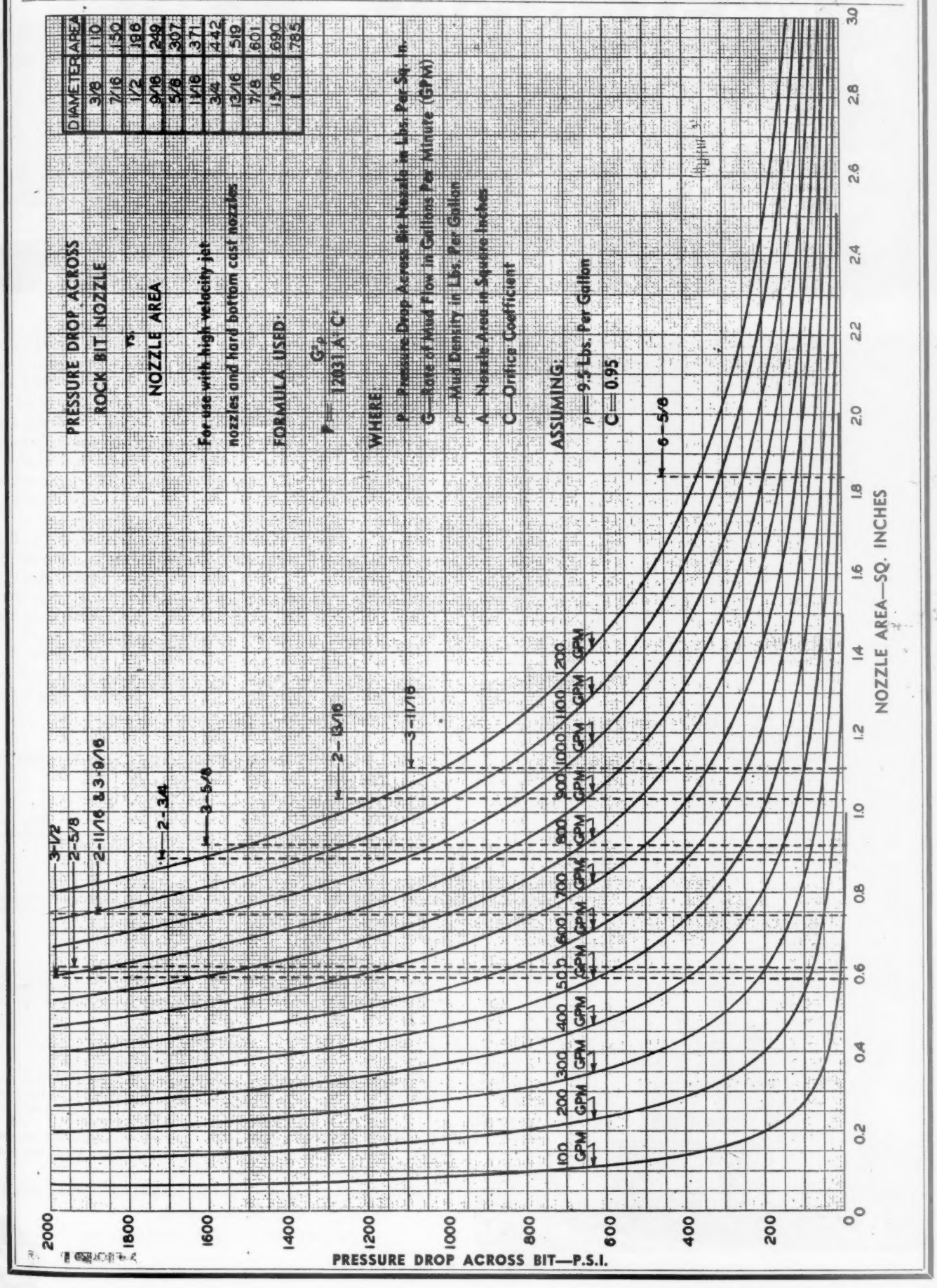
DRILLING HYDRAULICS

Courtesy of Hughes Tool Company.



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IN THE ART OF STEELMAKING—

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DEEP well drilling demands the utmost in strength of tubular materials. They must be worked hard, deep—must resist fatigue, twisting action, collapse. And they must always be capable of meeting the higher stresses of tomorrow.

National Seamless Oil Country Tubular Products are acknowledged the world over as the most ideal material for deep well work, from the standpoint of both steel quality and method of manufacture—for, in effect, this very method of manufacture is in itself a severe test of the uniformity and strength of the steel.

Manufacturing a seamless tube by the piercing method is one of the most difficult forging operations in the steel industry. Only steel of the very best forging properties and of high uniformity can be used for the seamless process, since piercing the solid billet tends to search out any defects in the metal. Consequently, as the art of steelmaking has improved, so has the quality of the steel used for NATIONAL seamless. The result—a masterpiece of high strength, high collapse resistance, and maximum security—National Seamless Oil Country Tubular material.

Significant National Tube Developments in the Oil and Gas Industry:

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Especially well-suited for oil production because of its combination of high yield strength and good ductility.

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An extremely high-strength casing possessing a uniformity of physical properties which gives it high collapse resistance and greatly increased joint strength.

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A stronger casing than is provided under A.P.I. specifications, to meet constantly increasing depths. Because it is intended for severe service it is hydrostatically tested to 80% of minimum yield strength up to a maximum of 12,000 p.s.i.

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Developed to satisfy the need for a casing joint which will safely and economically support the weight of deep-well casing. The buttress-thread joint is comparable in strength to that of the body of the pipe.

For further information on National Tube developments in the oil industry, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

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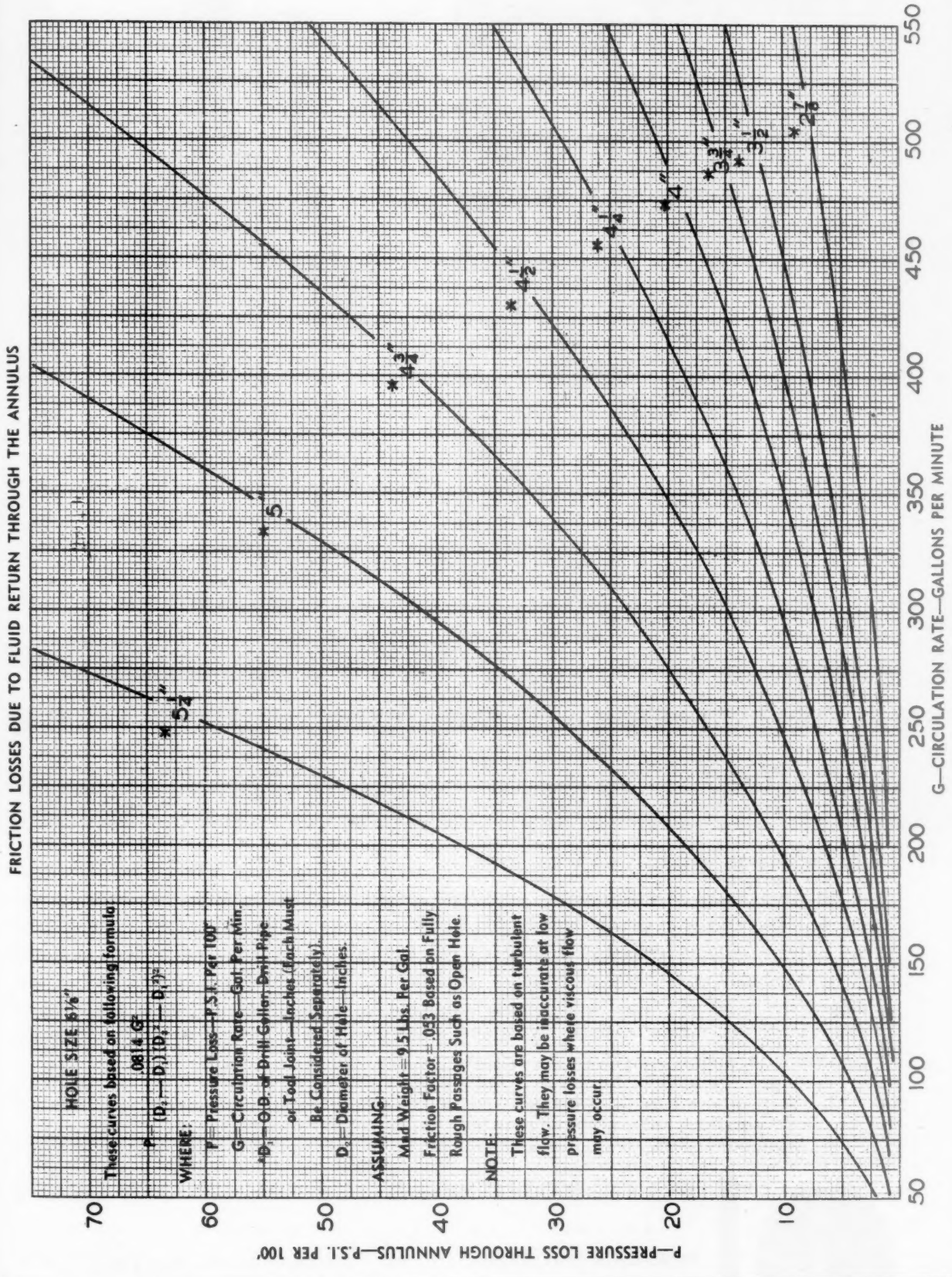
PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

USS NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL

DRILLING HYDRAULICS



Courtesy of Hughes Tool Company

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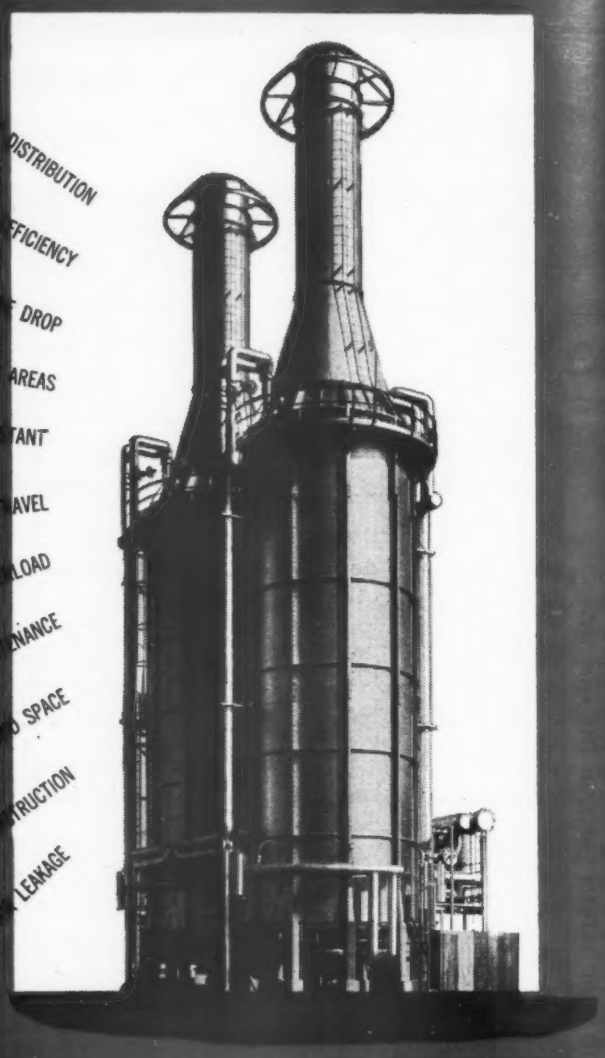
MINIMUM GROUND SPACE
SIMPLICITY OF DESIGN AND CONSTRUCTION
ZERO GAS LEAKAGE



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CUBIC YARD PER MINUTE (Continued)

1.0	cubic yards per minute
0.016667	cubic yards per second
6,924.960	barrels per day
288.540	barrels per hour
4.80897	barrels per minute
0.080150	barrels per second
11,009.66399	hektoliters per day
458.73560	hektoliters per hour
7.64559	hektoliters per minute
0.12743	hektoliters per second
38,880	cubic feet per day
1,620	cubic feet per hour
27.0	cubic feet per minute
0.450	cubic feet per second
110,096.63994	dekaliters per day
4,587.3600	dekaliters per hour
76.45595	dekaliters per minute
1.27427	dekaliters per second
290,842.2720	gallons per day
12,118.4280	gallons per hour
201.97350	gallons per minute
3.36623	gallons per second
242,179.20	gallons (Imperial) per day
10,090.80	gallons (Imperial) per hour
168.18003	gallons (Imperial) per minute
2.80300	gallons (Imperial) per second
1,100,966.39942	liters per day
45,873.59998	liters per hour
764.55945	liters per minute
12.74267	liters per second
1,100,966.39942	cubic decimeters per day
45,873.59998	cubic decimeters per hour
764.55945	cubic decimeters per minute
12.74267	cubic decimeters per second
1,163,367.36	quarts per day
48,473.64	quarts per hour
807.8940	quarts per minute
13.4649	quarts per second
2,326,734.72	pints per day
96,947.28	pints per hour
1,615.7880	pints per minute
26.9298	pints per second
9,306,938.88	gills per day
387,789.12	gills per hour
6,463.152	gills per minute
107.71920	gills per second
11,009,663.99424	deciliters per day
458,735.99976	deciliters per hour
7,645.5945	deciliters per minute
127.42667	deciliters per second
67,184,640	cubic inches per day
2,799,360.0	cubic inches per hour
46,656.0	cubic inches per minute
777.6	cubic inches per second
110,096,639.9424	centiliters per day
4,587,359.9976	centiliters per hour
76,455.945	centiliters per minute
1,274.26667	centiliters per second
1,100,966,399.424	milliliters per day
45,873,599.976	milliliters per hour
764,559.45	milliliters per minute
12,742.66667	milliliters per second
1,100,966,399.424	cubic centimeters per day
45,873,599.976	cubic centimeters per hour
764,559.45	cubic centimeters per minute
12,742.66667	cubic centimeters per second
1,100,966,399,424	cubic millimeters per day
45,873,599,976	cubic millimeters per hour
764,559,450	cubic millimeters per minute
12,742,666.67	cubic millimeters per second

DECILITER =

0.0001	kiloliters
0.0001	cubic meters
0.0001308	cubic yards
0.00062900	barrels
0.001	hektoliters
0.0028380	bushels (U. S.)
0.0027513	bushels (Imperial) dry
0.0035316	cubic feet
0.01	dekaliters
0.011352	pecks
0.026418	gallons (U. S.) liquid
0.022706	gallons (U. S.) dry
0.021997	gallons (Imperial)
0.10567	quarts (liquid)
0.090816	quarts (dry)
0.1	liters
0.1	cubic decimeters
0.18163	pints (dry)
0.21134	pints (liquid)
0.84536	gills (liquid)
6.1025	cubic inches
1.0	centiliters
100	milliliters
100	cubic centimeters
100,000	cubic millimeters
3.38147	ounces (fluid)
27.05179	drams (fluid)

FOOT PER DAY =

0.0001893939	miles per day
0.0000078914	miles per hour
0.00000013152	miles per minute
0.0000000021921	miles per second
0.0003048006	kilometers per day
0.0000127	kilometers per hour
0.00000021167	kilometers per minute
0.0000000035278	kilometers per second
0.00151515	furlongs per day
0.000063131	furlongs per hour
0.0000010522	furlongs per minute
0.000000017536	furlongs per second
0.003048006	hektometers per day
0.000127	hektometers per hour
0.0000021167	hektometers per minute
0.000000035278	hektometers per second
0.0151515	chains per day
0.00063131	chains per hour
0.000010522	chains per minute
0.00000017536	chains per second
0.03048006	dekameters per day
0.00127	dekameters per hour
0.000021167	dekameters per minute
0.00000035278	dekameters per second
0.0606061	rods per day
0.0025253	rods per hour
0.000042088	rods per minute
0.00000070146	rods per second

Compiled by Steven Gerolde, Gulf Oil Corporation

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PURCHASED

Electric Power

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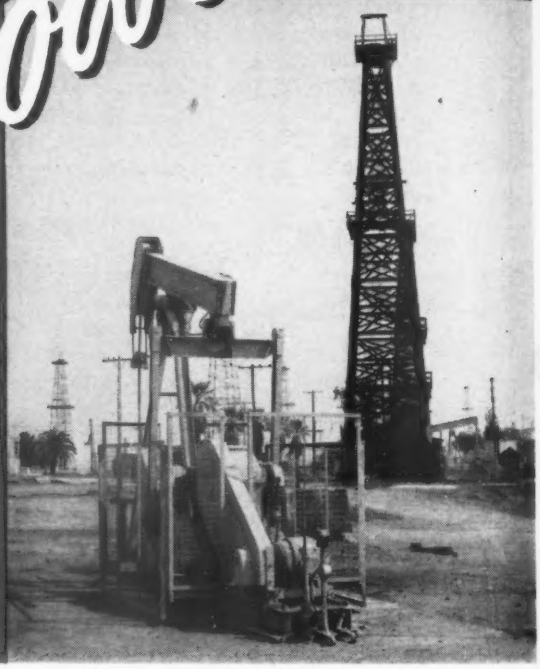
Cheaper



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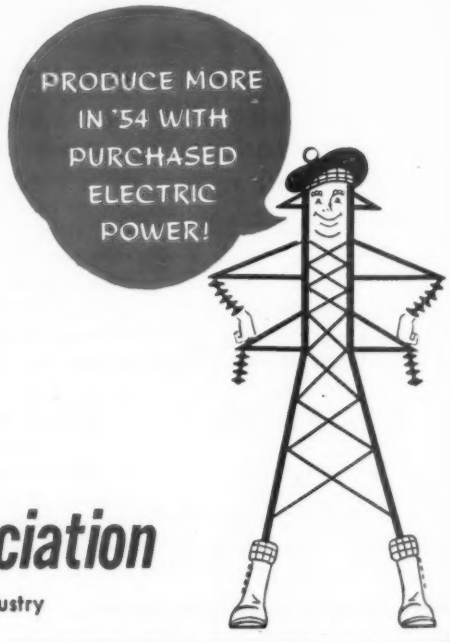


Petroleum Electric Power association

ORGANIZED in the interest of greater service to the petroleum industry

To obtain more information on products advertised see page E-57

CORRESPONDING DIFFERENTIALS—EQUAL FLOWS

FOR 3-IN. FLANGES — SIZE OF ORIFICE TO BE INSTALLED, IN.

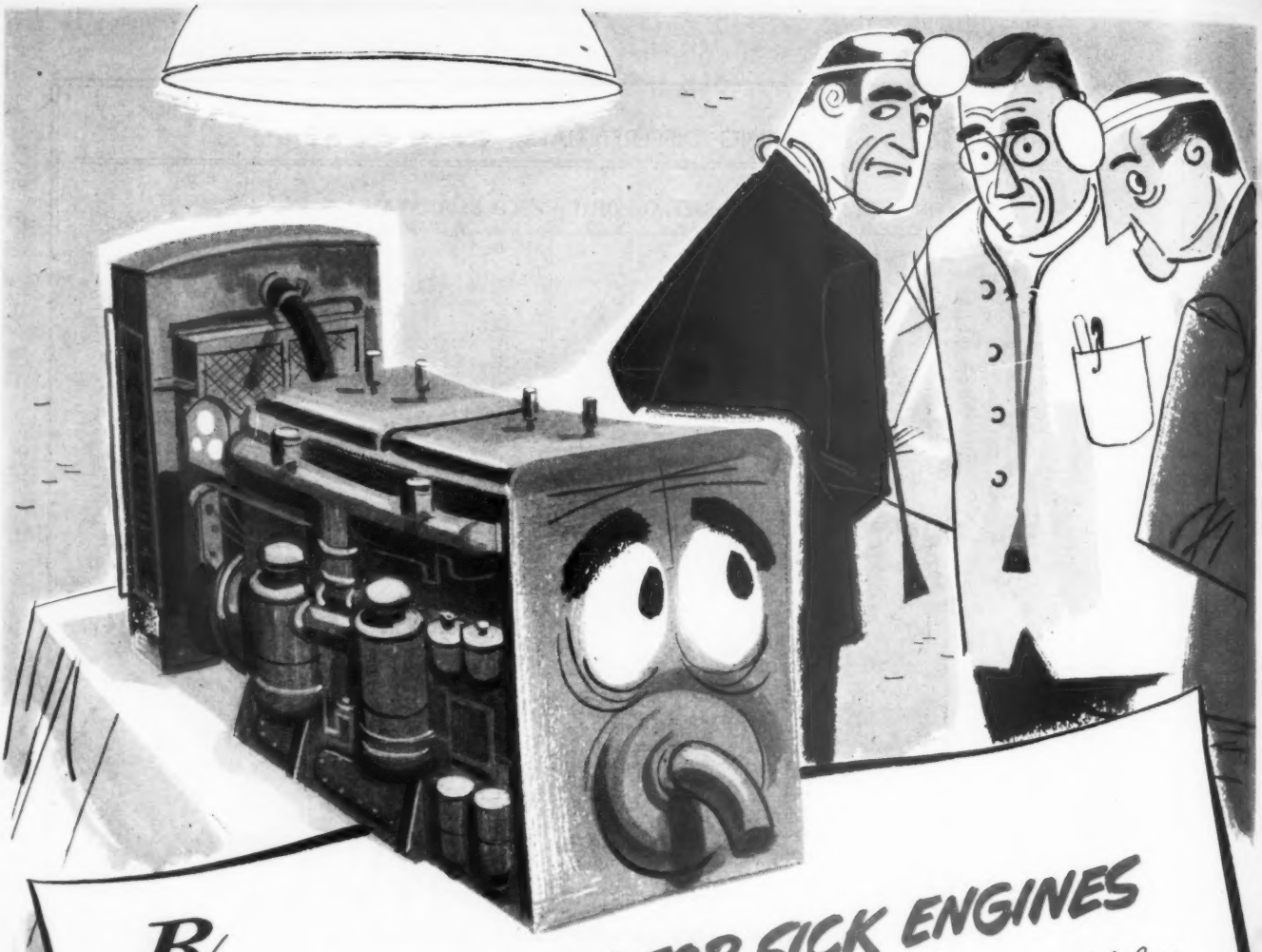
Size of orifice plate in use, in	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/4
1/4	1.0	.20	.06	03	.01							
3/8	5.1	1.0	.32	.13	.06	.03						
1/2	16	3.2	1.0	.41	.20	.11	.06	.03	.01			
5/8	39	7.7	2.4	1	.48	.26	.15	.06	.03	.01		
3/4	81	16	5.1	2.0	1	.54	.32	.13	.06	.03		
7/8		30	9.4	2.9	1.8	1	.59	.24	.10	.05	.03	.02
1		50	16	4.9	3.2	1.7	1	.41	.19	.09	.05	.03
1 1/4			39	12	7.7	4.2	2.4	1	.46	.20	.08	.06
1 1/2			83	34	16	8.9	5.2	2.1	1	.34	.27	.20
1 3/4				69	33	18	9.4	4.3	2.0	1	.53	.39
2					63	34	20	12	3.6	1.8	1	.7
2 1/4						46	26	16	4.9	2.5	1.3	1

FOR 2-IN. FLANGES — SIZE OF ORIFICE TO BE INSTALLED, IN.

Size of orifice plate in use, in.	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
1/4	1	.20	.06	.03	.01						
3/8	4.9	1	.31	.12	.06	.03	.02				
1/2	16	3.1	1	.40	.19	.10	.06	.03	.02		
5/8	39	7.8	2.5	1	.47	.25	.14	.08	.05	.03	.02
3/4	82	17	5.2	2.1	1	.52	.32	.18	.11	.07	.05
7/8		31	9.9	4.0	1.9	1	.57	.34	.21	.13	.09
1		55	17	7.0	3.3	1.8	1	.60	.37	.24	.15
1 1/8		92	29	12	5.6	2.9	1.7	1	.62	.39	.25
1 1/4			47	19	9.0	4.7	2.7	1.6	1	.63	.41
1 3/8			74	30	14	7.5	4.3	2.5	1.6	1	.64
1 1/2				47	22	12	6.7	4.0	2.5	1.6	1

Formula: Multiplier = ratio of squares of orifice coefficients.

Example: If plate changed from 2-in. by .50-in. to a 2-in. by .75-in. the differential multiplier would be $\frac{(51.7)^2}{(117.8)^2} = .19$. Therefore, if the differential was reading 95-in. with the 2-in. by .50-in. plate, it would read 18-in. with the 2-in. by .75-in. plate.



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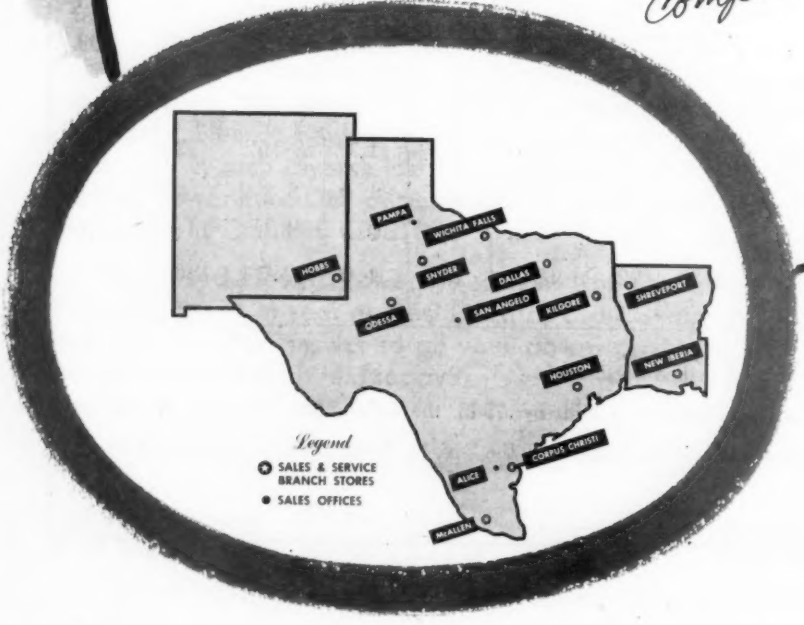

WAUKESHA

Sales & Service, Inc.

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EXCLUSIVE DISTRIBUTORS FOR WAUKESHA PRODUCTS IN TEXAS, NORTH AND WESTERN LOUISIANA, SOUTHERN ARKANSAS AND NEW MEXICO

CORRESPONDING DIFFERENTIALS—EQUAL FLOWS

FOR 4-IN. FLANGES—Size of orifice plate to be installed, in.

Size o. Orifice plate in use, in.	¼	⅜	½	⅝	¾	⅞	1	1¼	1½	1¾	2	2¼	2½	2¾	3
¼	1.0	0.20	0.06	0.03	0.01										
⅜	5.1	1.0	0.32	0.13	0.06	0.03									
½	16.0	3.2	1.0	0.41	0.20	0.11	0.06	0.03	0.01						
⅝	39.0	7.7	2.4	1.0	0.48	0.26	0.15	0.06	0.03						
¾	81.0	16.0	5.1	1.5	1.0	0.54	0.32	0.13	0.06	0.03					
⅞		30.0	9.4	2.9	1.8	1.0	0.59	0.24	0.12	0.06	.04	0.02			
1		50.0	16.0	4.9	3.2	1.7	1.0	.41	0.20	0.11	0.06	0.04	0.02		
1¼			39 0	12.0	7.7	4.2	2.4	1.0	0.48	0.26	0.15	0.09	0.05	0.03	0.02
1½			81.0	25 0	16.	8.6	5.1	2.1	1.0	0.54	0.31	0.18	0.11	0.07	0.04
1¾				46.0	30.0	16.0	9.4	3.8	1.8	1.0	0.57	0.33	0.20	0.12	0.08
2					52 0	28.0	17.0	6.8	3.3	1.8	1.0	0.59	0.35	0.21	0.13
2¼						44.0	28.0	11.0	5.6	3.0	1.7	1.0	0.60	0.36	0.23
2½							47.0	19.0	9.3	5.0	2.9	1.7	1.0	0.61	0.38
2¾								32.0	15.0	8.2	4.7	2.8	1.6	1.0	0.62
3								51.0	25.0	13.0	7.5	4.4	2.7	1.6	1.0

FOR 6-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use, in.	¾	⅞	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	4½	5
⅜	0.06	0.03													
½	0.20	0.11	0.06	0.03											
⅝	0.48	0.26	0.15	0.06	0.03										
¾	1.0	0.54	.32	0.13	0.06	0.03									
⅞	1.8	1.0	.59	0.24	0.12	0.06	0.04	0.02							
1	3.2	1.7	1.0	0.41	0.20	0.11	0.06	0.04	0.03						
1¼	7.7	4.2	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03				
1½	16.0	8.6	5.1	2.1	1.0	0.54	0.32	0.20	0.13	0.09	0.06	0.03			
1¾	30.0	16.0	9.4	3.8	1.8	1.0	0.59	0.37	0.21	0.16	0.11	0.06	0.03		
2	51.0	27 0	16.0	2.6	3.2	1.7	1.0	0.62	0.41	0.28	0.19	0.09	0.05	0.03	
2¼		44.0	26.0	10 0	5.1	2.7	1.6	1.0	0.66	0.44	0.31	0.15	0.08	0.04	
2½			39.0	16.0	7.7	4.2	2.4	1.5	1.0	0.63	0.47	0.23	0.12	0.06	
2¾			58.0	24.0	11.0	6.2	3.6	2.3	1.5	1.0	0.69	0.34	0.17	0.09	
3				34 0	17.0	8.9	5.2	3.3	2.1	1.4	1.0	0.50	0.25	.13	
3½				69.0	33 0	18.0	11.0	6.6	4.3	2.9	2.0	1.0	0.51	0.27	
4					65.0	35.0	21.0	13.0	8.5	5.8	4.0	2.0	1.0	0.53	
4½						67.0	39.0	25.0	16 0	11.0	7.5	3.7	1.9	1.0	

FOR 8-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use in.	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	4½	5	5½	6
1	1.0	.41	0.20	0.11	0.06	0.04	0.03	0.02							
1¼	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03						
1½	5.1	2.1	1.0	0.54	0.32	0.20	0.13	0.09	0.06	.03					
1¾	9.4	3.8	1.8	1.0	0.59	0.37	0.24	0.16	0.12	0.06	0.04				
2	16.0	6.6	3.2	1.7	1.0	0.62	0.41	0.28	0.20	0.11	0.06	0.04			
2¼	26 0	10.0	5.1	2.7	1.6	1.0	0.66	0.45	0.32	0.17	0.10	0.06	0.03		
2½	39 0	16.0	7.7	4.2	2.4	1.5	1.0	0.68	0.48	0.26	0.15	0.09	0.05	.03	
2¾	57.0	23.0	11.0	6.1	3.6	2.2	1.5	1.0	0.71	0.38	0.22	0.13	0.08	0.05	0.03
3	81.0	33.0	16.0	8.6	5.1	3.2	2.1	1.4	1.0	0.54	0.31	0.18	0.11	0.07	0.04
3½		62.0	30.0	16.0	9.4	5.9	3.8	2.6	1.8	1.0	0.57	0.33	0.20	0.12	0.08
4			53 0	45.0	16.0	10 0	6.8	4.6	3.3	1.8	1.0	0.59	0.35	0.21	0.13
4½			89.0	48.0	28.0	18 0	12.0	7.9	5.6	3.0	1.7	1.0	0.60	0.36	0.23
5				80.0	47.0	29.0	19.0	13.0	9.3	5.0	2.9	1.7	1.0	0.61	0.38
5½					77.0	48.0	32.0	22.0	15.0	8.2	4.7	2.7	1.6	1.0	0.62
						77.0	51.0	35.0	25.0	13.0	7.5	4.4	2.6	1.6	1.0

Example: The highest differential reading on a 4 in. by 2 in. orifice plate is 10 in. on a 100-in. chart. It is desired to install a 4 in. by 1½ in. orifice plate. What will be the differential on the chart with the 4 in. by 1½ in. orifice plate installed.

In the 4 n. flange section of the table find the 2-in. orifice size. Under the 1½-in. orifice size, where the columns intersect find 3.3. Multiply by 10 and the new differential reading is 33 in. for the 4 in. by 1½ in. plate.

OIL and GAS TRADE NEWS

Lane-Wells Opens Branch

Lane-Wells Company has opened a new branch in Bartlesville, Oklahoma. Quarters for the new office have been taken at 1701 West Fifth Street. Robert D. Johnson is in charge of the new location. Kenneth W. Simmons is district sales engineer. Charles A. Berquist and Fred A. Soule are members of the staff.

ACF Elects Officers

At the annual stockholder's meeting of ACF Industries, Inc., the slate for the board of directors was elected. Over 87 per cent of the presently outstanding shares were voted. Charles J. Hardy, Jr., was elected chairman of the board. James F. Clark was elected president.

OCT Opens Branch

A new permanent sales and service branch which will serve the Rocky Mountain-Williston area has recently been opened by Oil Center Tool Company at Casper, Wyoming. M. E. (Mike) Hunter is district manager in charge of the new OCT branch. Harry McDow is sales representative.

Export Distributor Named

Chicago Pneumatic Tool Company has appointed the Petroleum Machinery Corporation as exclusive export distributors for its oil tool division.

New Division Formed

Establishment of the western division of Glass Fibers Inc., with full responsibility for administrative, manufacturing and sales activities in eleven western states has been announced. M. Dean Worcester has been appointed general manager of the division. John T. Podorean has been advanced to general sales manager of the division.

A valve engineer inspecting one of the valve displays in the Edward Valvemobile, the mobile valve school designed by Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company. The Valvemobile just recently completed a 3-month, 5000-mile tour in the Southwest and now has departed for the Atlantic coast states.

Lane-Wells Station Opened

Lane-Wells Company has opened a new truck station at 803 North Jackson, Pratt, Kansas. Jack Gray has been appointed station superintendent.

Inco Sections Formed

Establishment of four new sections and other changes in the development and research division of The International Nickel Company, Inc., has been announced. The new sections are: Constructional alloy steels section, with H. V. Beasley in charge; electroplating section, with Clarence H. Sample in charge; Inco nickel alloys development section, with T. E. Kihlgren in charge, and stainless steel and heat-resistant alloys section, with V. N. Krivobok in charge.

New Company Formed

A new patented process of injection molding of unplasticized polyvinyl chloride will be used exclusively by a company just organized, Tube Turns Plastics, Inc., in the manufacture of industrial plastic pipe fittings and custom molded products. Company, which will be located in Louisville, Kentucky, was established jointly by Tube Turns Division of National Cylinder Gas Company and Jackson and Church Company.

Trane Moves Sales Office

The Trane Company has moved its sales office in Greenville, South Carolina, to the Shives Building, 644 E Stone Avenue. R. G. Beck is the Trane sales engineer in charge of this office.

Corrosion engineers of the Columbia Gas System and its subsidiaries recently toured the Waterville, Ohio, plant of Glass Fibers Inc. Members of the group at a luncheon given by Glass Fibers Inc. were: (Standing) M. W. Gregory, Glass Fibers Inc.; R. W. Capaul, vice president, Glass Fibers Inc.; Frank Costanzo, Manufacturers Light and Heat; James Hopkins, Ohio Fuel Gas; Herbert Byrnes, Columbia Gas Systems Service Corporation; George Orr, United Fuel Gas Company, and William Kretchmer, Columbia Gas Systems. (Seated) John Keenan, Waterville plant manager; Thomas A. Collins, executive vice president, Glass Fibers Inc., and Edward Davis, Ohio Fuel Gas Company. **Above: Oil industry executives** who flew to recent API meeting and barbecue at Midland, Texas, in the McCullough Tool Company "Lodestar" plane were: Earl McNeil, Tennessee Production Company; Bishop "Blackie" Craddock, Honolulu Oil Company; William J. Murray, Jr., Commissioner, Railroad Commission of Texas and main speaker; A. S. Donnelly, Honolulu Oil Company, and Russell Hays, Phillips Petroleum Company.

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Trade News

Company Changes Hands

Officers and area managers of United Geophysical Company have formed a new company for the purpose of purchasing the business and assets of the present corporation from the owner, Union Oil Company of California. There will be no change in the personnel, equipment, laboratory facilities, or policies of the new company. Organization will be entirely independent and wholly owned by the active management.

Service Office Opened

A new service location in the Mississippi Delta has been established by Schlumberger Well Surveying Corporation. New location is designed to give more prompt service in the delta area.

Export Office Transferred

Johnston Testers has moved its export sales offices from Los Angeles, California, to Houston, Texas. Move is in line with policy to locate personnel in Houston.

Jet-Lube Forms Company

Jet-Lube of Canada, Ltd., an Edmonton corporation, has been established to manufacture Jet-Lube lubricants for the oil field, aviation, automotive, mining, marine, and diversified industrial uses throughout the Dominion under exclusive license agreement with Jet-Lube, Inc., of California. Officers and directors of the Canadian firm are: W. L. Falkner, president; H. E. Snelson, vice president and managing director; J. F. Langston, secretary-treasurer, and W. F. Knode, director.

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Distributors Appointed

Owens-Corning Fiberglas Corporation has announced it has completed its Kaylo distributor-contractor organization to serve 48 states, the District of Columbia, and Alaska. Company said it has appointed 57 distributor-contractors of Kaylo industrial heat insulations. Owens-Corning last year was appointed as a national distributor of Kaylo heat insulations which are manufactured by Owens-Illinois Glass Company.

Fuller Company Purchased

General American Transportation Corporation of Chicago has announced the execution of a contract for the acquisition of the Fuller Company of Catasauqua, Pennsylvania. Transfer includes Fuller Company's wholly-owned subsidiaries, Hershey Machine and Foundry Company, of Manheim, Pennsylvania, and Separation Process Company, of Catasauqua.

U. L. Approves Pump

Chempump Corporation has announced that their seal-less, leak-proof centrifugal pumps have been listed by Underwriters' Laboratories for explosion proof operation with hazardous liquids and in hazardous atmospheres.

Grove Moves Headquarters

Los Angeles offices of Grove Regulator Company have been relocated at 1930 West Olympic Boulevard, according to an announcement released by the firm's central office in Oakland, California. F. H. Wehrman, district manager for Grove Regulator Company, will continue to head the Los Angeles office.

Onan Displays Vehicle

A new demonstrator-display van, aptly titled the Onan Powerhouse, has recently been completed and will soon be on display at Onan distributors and dealers showrooms throughout the country. Van was designed as a complete, self-contained travelling display to demonstrate the operation and maintenance of Onan electric generating plants.

IDECO Appointed Agent

IDECO, one of the Dresser Industries, has been appointed exclusive export distributor for Mayhew portable rotary drilling equipment. IDECO will also distribute the MAYHEW products domestically on a non-exclusive basis, it was announced.

Wheland Appoints Agent

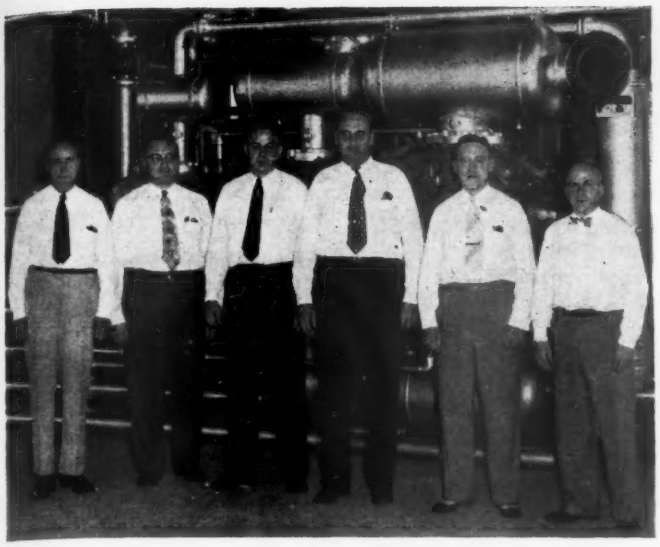
The Houston Oil Field Material Company is now a distributor for the Wheland Company. New distributorship agreement was signed recently at Homco's home office in Houston. Addition of Homco as a distributor is part of a new sales program recently inaugurated by Wheland.

New Division Created

Cooper-Bessemer has formed three primary engineering divisions. Known as the development division, technical division, and product division, the activities of each division will be directed by its own chief engineer.

Pump Distributor Named

The Frank Wheatley Supply Company has been appointed exclusive distributor for Marquette Rotary Pumps in the Mid-Continent area. Territory includes the states of Kansas, Oklahoma, Texas, Arkansas, Louisiana, and Mississippi.



The Cooper-Bessemer Corporation and Southwest Industries, Inc., recently held a sales meeting in Houston, Texas. Representatives of Cooper-Bessemer present were: A. A. Burrell, vice president; Dennis Gallogly, engineering department; Harold C. Johnson, factory superintendent; Robert F. Lay, general sales manager; Stanley E. Johnson, Sr., vice president, and R. F. Kymer, engineering department.

ACC Forms Departments

Creation of two new departments of American Cyanamid Company's Research Division have been announced. They are: The basic research department and the research service department. D. J. Salley was named assistant director of the basic research department, and R. H. Kienle was named director of the research service department. R. P. Chapman will be assistant director of the department.

Lane-Wells Expands Office

General expansion of the home office and plant facilities of Lane-Wells Company in Los Angeles, California, and the enlargement and more efficient use of buildings to provide greater service for customers have been announced. Engineering and patent departments have been enlarged, new test pits, and other facilities installed. Sales department has been moved to new and enlarged quarters in its own building and shipping department and steel storage departments have been reorganized and other changes made.

G. E. Raises Production

The General Electric Company has announced that it is tooling for mass production — in the millions — of low cost, exceptionally high frequency transistors.

Dow Laboratories Begun

Construction of new, ultra-modern laboratories to house its biochemical research department has begun at Midland, Michigan, by The Dow Chemical Company. The structure, 208 by 190 ft, will provide 40,000 sq ft of laboratory space for the department's 5 sections. Completion is expected within a year.

Gaso Names Distributor

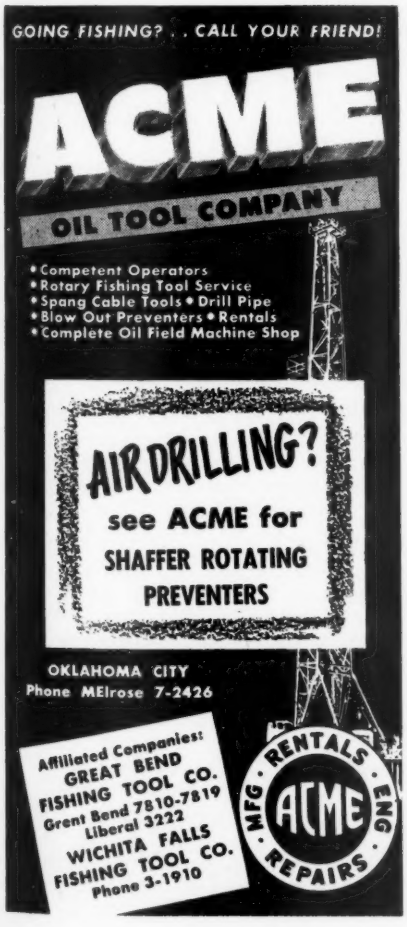
Gaso Pump and Burner Manufacturing Company has announced the appointment of Power Pumps, Incorporated, as Pacific Coast distributor for Gaso Pumps. Headquarters of Power Pumps, Inc., are at 3273 Cherry Ave., Long Beach, California, where complete stocks of Gaso Pumps and parts will be maintained.

Bucyrus-Erie Profits Up

Net earnings of $2,985,139, or $1.92 per share of common stock outstanding were reported by Bucyrus-Erie Company for the 6 months ended June 30, 1954. This compares with net earnings of $2,844,715 or $1.83 per share for the corresponding period in 1953. Shipments during the period totaled $37,671,655 or 18.2 per cent below the $46,029,028 shipped in the first 6 months of last year.

GE Appoints Distributor

Dietz Industrial Supply Company, Aurora, Illinois, has been named an authorized distributor for the Carboloy department of General Electric Company. Organization will carry department's entire line of standard cemented carbide tools and blanks, carbide-tipped masonry drills, and diamond wheel dressers.



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Trade News

G. E. Premiers Film

A new version of "Clean Waters," a film calling attention to pollution of water resources, will be premiered by the General Electric Company at the annual meeting of the Federation of Sewage and Industrial Wastes Association in Cincinnati, October 10 through 14. Picture is designed to create an awareness to the growing of stream pollution and enlist public and industry support.

Girdler Expands Facilities

The Girdler Company has begun the erection of a major addition to its catalyst plant. It is adjacent to the company's activated carbon plant, built in 1952. Addition is scheduled for completion and use late in 1954, or early in 1955.

Davison Holds Meeting

Distributors and agents representing Davison Chemical Company Division of W. R. Grace and Company, in the sale of Davison's Protek-Sorb silica gel desiccant for dehydrated packaging, were guests of the company at a two-day sales meeting in Baltimore, Maryland. Plans for the expansion of the market for the product were discussed.

Rollin Company Purchased

Byron Jackson Company, has purchased Rollin Company of Pasadena, California. Rollin has specialized development and manufacture of precision testing equipment used to evaluate and standardize the performance of electronic operating equipment and measuring devices.

Condensing Unit Installed

A Worthington Corporation condensing unit installed at Phillips Chemical Company's Pasadena, Texas, plant by Chemical Construction Corporation, is first Anhydrous Ammonia centrifugal condensing unit to be installed in any U. S. plant. Two Worthington GUR 3R-6 centrifugal ammonia compressors, each driven by a 2500 hp 9140 rpm Worthington type "T" non-condensing steam turbine, provide 3000 tons of ammonia refrigeration at 14 F evaporator and 100 F condensing temperature.

Giant Tires Made

United States Rubber Company is now making, in its Detroit plant, the largest tires in its history—tires that weigh 2600 lb and stand 8 ft tall—for use on huge earth-moving and strip mining equipment, bottom dump trucks, and self-loading scrapers. These nylon tires are 30.00-33 in size and have a 40-ply rating. The new giants are called U. S. Royal Con-Trak-Tors.

Trading Water for Oil

A trick called "five-spotting" and the right kind of pump according to J. E. Lovegreen of Worthington Corporation's St. Louis Office, can recover from an abandoned oil field a volume of oil equalling or exceeding the original production of the primary well. "Five-spotting" involves the drilling of four wells around a depleted well and pumping water into the center well in an attempt to use the water pressure to produce oil.

TerraTrac Receives Capital

American Tractor Corporation (TerraTrac) has secured $500,000 in additional working capital, with promise of more as needed. Financing was arranged by Elliott and Company, members of the New York Stock Exchange, in conjunction with the Marine Midland Trust Company, of New York City. Elliott and Company recently selected TerraTrac as having the "greatest growth potential of any company in the industrial field."

McCullough Opens Branch

McCullough Tool Company has opened a new service branch at Harvey, Louisiana. Orwin E. Petty has been appointed branch manager. Petty has been employed for the past four years in the McCullough eastern division headquarters at Houston in the research and development department.

Color Film Completed

American Cast Iron Pipe Company has completed a 16mm sound motion picture in color entitled "Acipco Steel Centrifugally Spun Tubes."

BS&B Sales Rise

Record sales and net profits have been reported by Black, Sivalls and Bryson, Inc., for the first half of 1954. A 12 per cent sales gain carried the net profits 48 per cent above a year ago. Consolidated net sales for the 6-month period were $23,601,978, against $21,075,716 a year earlier.

Ruberoid Declares Dividend

The Ruberoid Company has declared a regular dividend of 40¢ per share on the corporation's outstanding capital stock. It was payable September 14, 1954, to stockholders of record at at the close of business on September 3, 1954.

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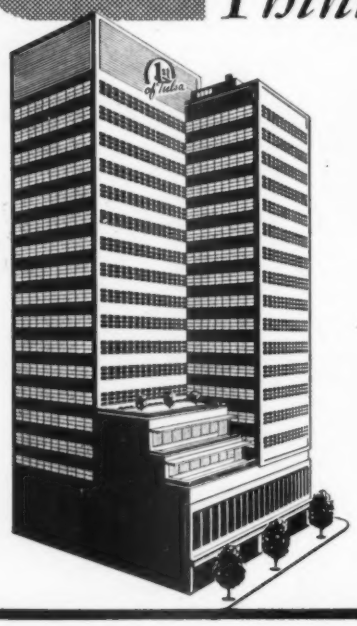

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TRADE PERSONALS

William R. Hainsworth has been appointed vice president in charge of the research division of The Fluor Corporation, Ltd. Hainsworth joined the company in 1952, and had served since that time as technical advisor to the executive vice president. He was formerly vice president of the engineering division for Servel, Inc., and is a past chairman of the Industrial Research Institute.

C. J. Chapman

E. L. Dribble

C. J. Chapman has been appointed general sales manager, industrial products, of National Carbon Company, a division of Union Carbide and Carbon Corporation. Chapman, a graduate of Dartmouth College, joined National Carbon Company in 1936 as a salesman in the eastern district. Prior to his appointment he was Chicago district sales manager.

E. L. Dibble has been appointed general sales manager, consumer products. He joined National Carbon Company as a salesman in Portland, Oregon, in 1934. In 1952 he was made manager of the eastern district, the position he held until his present appointment.

J. T. Tucker has been elected vice president in charge of sales for Unit Rig and Equipment Company. **J. L. Vint** has been elected vice president in charge of engineering, and **K. W. Patterson** was elected vice president in charge of manufacturing.

Tucker joined Unit Rig in the summer of 1953 as general manager of sales. J. L. Vint has been the company's chief engineer. He attended both the University of Wichita and University of Kansas. K. W. Patterson joined Unit Rig in May 1953 as assistant to the president, and has been associated with the manufacturing of both aircraft and oil field equipment since 1941.

Robert W. Bowles has been named manager, specialty steel sales, for the Kaiser Steel Corporation. Bowles joined the Kaiser organization in 1941, in the plant maintenance department of the Richmond shipyards. Prior to his recent appointment, he was assistant to the manager of engineering sales. Bowles attended Stanford University.

Colman Curtiss, Jr., has joined The S. M. Jones Company, division of Buffalo-Eclipse Corporation. He will be a vice president of the Jones Company, succeeding the late **Frank S. Oatman.** Curtiss, a graduate of Yale University, has been with the Buffalo Bolt division of the Buffalo-Eclipse Corporation for 20 years.

John W. Bolton has retired as chief metallurgist and research director of The Lunkenheimer Company. **Marvin L. Steinbuch** has been appointed as his successor.

Bolton directed Lunkenheimer's metallurgical research and testing division for the past 27 years. He joined Lunkenheimer as chief metallurgist in 1926. Steinbuch joined Lunkenheimer's metallurgical research and testing division in 1947. He was appointed departmental head of the structural metallurgy in 1952, and assistant director of the division prior to being named to his new post. Steinbuch is a graduate of the University of Cincinnati.

W. Y. "Red" Cadwallader has been employed by Technical Oil Tool Corporation to serve Totco users in the Bakersfield-San Joaquin, California areas. **P. Taylor Bannerman,** formerly with Totco in Bakersfield, has been appointed purchasing agent at the Totco home office and plant in Los Angeles, California. **John Davis** has been named California division manager with headquarters in Los Angeles. **Dale Ernest** has been moved from Hobbs, New Mexico to Pratt, Kansas. Ernest will serve all of the supply stores carrying the Totco line in Kansas.

Marvin Gearhart has been named to the post of head regional field engineer for Security Engineering Division, one of the Dresser Industries. Gearhart joined Security in 1953. Prior to his recent promotion, he was Security's chief regional field engineer for the Western Region.

Bill Schacht has been appointed to the post of chief sales statistician. Schacht joined Security in 1947. Prior to his recent promotion, he held various responsible positions in the company, including extensive work in Security's sales control department.

Arthur McLawhon

R. E. McCullough

Arthur McLawhon, formerly assistant to the president, was elected a vice president of Republic Supply and assigned the newly aestablished responsibility of comptroller of the company. **R. E. McCullough,** formerly purchasing agent, was promoted to assistant to the president. Replacing McCullough is **R. J. Hood,** formerly associated with Brown and Root, Inc.

Clark Munger has been appointed advertising and sales promotion manager for Barnes Manufacturing Company. Before joining Barnes, Munger spent seven years with Westinghouse as housewares advertising supervisor. He is a graduate of Bowling Green University.

Joseph Tykodi has been appointed factory sales representative for Axelson Manufacturing Company's western New York territory. Before joining the Axelson organization Tykodi was a sales-service representative with the Warner and Swasey Company.

Robert Bader has been appointed sales engineer at Houston, Texas for the welding fittings division of the Bonney Forge and Tool Works. Prior to his assignment to Houston, Bader served with Bonney's eastern sales division.

A. P. McGraw has been appointed regional manager for the northeastern region of Assemblies and Component Sales, which is the selling organization for the distribution assemblies and Trumbull components departments of General Electric. McGraw joined the General Electric Company in 1939 as a salesman for the Richmond, Virgina office of Apparatus Sales.

G. F. Klein, Jr.

G. W. Overstreet

George F. Klein, Jr., has been appointed manager of the process engineering department of Catalytic Construction Company. Klein was chief engineer of Spencer Chemical Company. He graduated from the University of Missouri with a BA in chemical engineering.

George W. Overstreet has been appointed sales representative in North and South Carolina and portions of Tennessee and Georgia for Wolverine Tube, Division of Calumet and Hecla, Inc. Overstreet was formerly plant sales manager in the company's Decatur, Alabama mill.

R. J. Hood

L. Galien

L. "Smokey" Galien has been appointed factory field representative for Lebus Rotary Tool Works, Inc.

Galien, who has been associated with the oil industry for 27 years, was formerly with McCullough Tool Company before joining LeBus.

Thomas O. Carson, manager of Rockwell Manufacturing Company's international division at New York City for the past five years, has been promoted to assistant product manager of Nordstrom Valves. Carson joined Rockwell as a sales engineer in 1945. He was formerly employed as a water meter salesman by Phoenix Meter Corporation.

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Alvin R. Reinarz has been promoted to administrative engineer and **Richard N. Cordrey** to chief designer at the Toledo, Ohio, plant of The National Supply Company. Reinarz joined the company in 1937. He was transferred to Toledo last year and has been acting as an administrative engineer for several months. He is a graduate of Texas A and M with a mechanical engineering degree. Cordrey joined the company in 1944 and has been engaged in development and production work on the company's drilling rigs. He has a mechanical engineering degree from the University of Toledo.

J. D. McLaughlin

J. F. Ormond

J. D. McLaughlin, former division sales manager, for Cardinal Chemical, Inc., has been placed in charge of overall engineering and equipment. **James F. Ormond** was promoted from sales and development engineer to division sales manager.

McLaughlin is a graduate of Oklahoma University and holds a degree in general engineering. Ormond is a graduate petroleum engineer (Tulsa University, '50).

William A. Depew has been appointed to the new position of claims manager for Kaiser Steel Corporation. He was formerly superintendent of the metallurgical engineering department at the company's steel plant in Fontana and was previously head of the plant's metallurgical and quality control departments.

R. P. Brown has been promoted from store manager of Mid-Continent Supply Company's Bowie, Texas, store to sales representative of the organization's Wichita, Kansas district. Brown joined the company in 1949 at its Magnolia, Arkansas store. He was transferred to Bowie as store manager this year. Brown attended the University of Southern California.

H. J. Corson has been named to the sales staff of the Protective Coatings Division, Pittsburgh Coke and Chemical Company. Prior to joining Pittsburgh Coke, Corson was associated with the Columbia Steel and Brass Corporation and prior to that with the Johns Manville Corporation. He is a graduate of New York University.

John P. Richmond, formerly comptroller, has been elected vice president in charge of finance of ACF Industries, Incorporated. Richmond succeeds **James F. Clark** who was elected president. **Paul M. Anderson** has been appointed assistant vice president.

Walter J. Conaty has been elected comptroller succeeding Richmond. Conaty has been manager of accounting since 1951. **David Ohler** was named an assistant treasurer of the company and **Frank F. Cleminshaw** and **John W. Hubbard** were named assistant comptrollers.

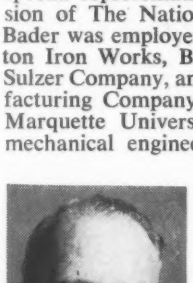
E. E. Childress, who has been sales manager of the Odessa, Texas branch of Stewart and Stevenson Services, Inc., for the last three years, has been transferred to the main plant at Houston, Texas where he will serve as chief engineer. Childress has been with Stewart and Stevenson for eight years. **N. J. "Tiny" Herman** has been transferred from the engineering department in Houston to the petroleum industry sales department for the Houston territory. **Grady Foster** has been transferred to the Lubbock, Texas branch where he will be sales manager. He was formerly in the sales department of the San Juan, New Mexico branch.

Edward C. Vorlander has been appointed managing director of Honeywell-Brown, Ltd., British subsidiary of Minneapolis-Honeywell Regulator Company. Vorlander has been with Honeywell for 22 years, serving in various administrative capacities. He formerly was administrative assistant to Tom McDonald, executive vice president.

John H. Hagen has been appointed director of industrial relations for the Brown Instruments division of Minneapolis-Honeywell Regulator Company. Hagen was formerly special assistant to the divisional president, Henry F. Dever. He joined the parent firm in 1933 in a Minneapolis factory position. Hagen attended the University of Minnesota.

Sam Ruvkun and **J. E. Hughes** have been appointed to the position of assistant to vice president of the Kaiser Engineers division of Henry J. Kaiser Company. Ruvkun was formerly a project engineer. Hughes joined the Kaiser organization in 1941 as engineer at the Richmond, Virginia shipyards.

G. L. Bader has been appointed a special representative of the engine division of The National Supply Company. Bader was employed formerly by the Fulton Iron Works, Baldwin-DeLaval, Bush Sulzer Company, and the Nordberg Manufacturing Company. He is a graduate of Marquette University, with a degree in mechanical engineering.



George Beach

George Beach has been promoted to the position of assistant to the sales manager of Cleco Pneumatic Tool Company's south central sales division. Division area includes Texas, Louisiana, New Mexico, Oklahoma, Arkansas, and Mississippi. Beach has been associated with Cleco since the opening of its air tool factory in Houston, Texas, in 1947. The Cleco Pneumatic Tool Company is a division of the Reed Roller Bit Company.

Walter St. Onge, Jr., has been appointed advertising manager of The Torrington Company. Member of the advertising department since 1953, St. Onge succeeds his father. He is a graduate of the University of Maine.

Beverly Houston has been appointed assistant controller for the De Laval Steam Turbine Company. Houston attended the Wharton School, University of Pennsylvania, and Rider College.

Trade Personals

I. M. Baker

R. C. Brooks

G. L. Teer

F. H. Hehemann

I. M. "Squirt" Baker has been appointed Cameron Valve and Oil Tool division sales manager for Mexico and South America. Baker was formerly division sales manager of the Houston, Texas division. **R. C. Brooks** replaces Baker as division sales manager for Cameron's Houston division. **G. L. Teer** has been transferred to Calgary, Alberta, Canada, as division sales manager, Cameron Iron Works of Canada, Ltd. Teer was replaced by **T. G. Roscoe** as Cameron's district sales manager in charge of the West Texas division.

Leonard Limon has been appointed manager of the industrial boiler feed department of Graver Water Conditioning Company. Limon joined Graver in 1949 in charge of the estimating department. He has an MS degree in chemical engineering from New York University.

Harold R. Fosnot has been named sales manager. Fosnot joined Graver upon graduation from Purdue University in 1935 and became a member of Graver's first training program. He was previously Chicago district manager, eastern sales manager and most recently assistant general sales manager.

Charles T. Everett has been appointed executive vice president and general manager of Beaver Pipe Tools, Inc., to succeed **W. A. Phillis,** president, who will retire in the near future. Everett was formerly associated with the aviation division of Bingham-Herbrand Company as vice president and general manager. He is a graduate of the University of Cincinnati.

W. C. "Bill" O'Neil has been appointed sales representative for Thornhill-Craver Company in the Houston, Texas territory. O'Neil will cover the East Texas and Gulf Coast areas. He was a sales representative for Gulf Supply Company for three years prior to joining Thornhill-Craver. He attended the University of Houston.

L. Jack Clarke has been named general sales manager, Leschen Wire Rope Division, H. K. Porter Company, Inc. Clarke has served the Leschen organization as field representative in the New Orleans area and as manager of the New York sales district.

Charles L. Simms has been appointed eastern division credit manager for McCullough Tool Company. Simms joined McCullough Tool Company in 1945. Prior to that he had been associated with Dickson Gun Plant.

Stuart A. Currie has been appointed manager of the new St. Louis, Missouri, office of American Cyanamid Company's Explosives department. Currie joined American Cyanamid in 1937 in the technical section of the explosives department. He attended the University of Pittsburgh.

Fred H. Hehemann, chief engineer for the Lunkenheimer Company is observing his 50th anniversary with the company. He joined the organization in 1904. Hehemann started in production at the Fairmount plant. He was transferred to the engineering department as a draftsman in 1909, promoted to chief draftsman in 1918, and appointed chief engineer in 1945.

Sam Worrall has been appointed manager of the Salem, Illinois, branch of Black, Sivalls and Bryson, Inc. Worrall has been with BS&B since May, 1952, having previously worked for Mid-Continent Supply Company. **Frank Black** has been assigned as branch manager at the Houston office. He joined BS&B in January, 1947. **Jimmy Crume** has been transferred from Salem, Illinois, to Carmi, Illinois, as sub-branch manager and sales representative. **Avin Teal** was recently named district engineer, Alice, Texas. Teal was formerly group leader and product development engineer in the oilfield engineering department.

Bud Bricmont has been transferred to Shreveport, Louisiana, as district engineer. **John Humphrey** has been transferred from Drumright, Oklahoma, to Borger, Texas, as sales and service representative at that point. **Jack Records** has been appointed field salesman BS&B, working out of Ardmore in the Oklahoma City district. **Wayne Robb** has been appointed as field salesman at Salem, Illinois.

Walter F. Brown has been promoted to assistant sales manager for the U. S. tires division of United States Rubber Company. Succeeding Brown as north-central division manager is **J. A. Napier,** who had been district manager at Pittsburgh, Pennsylvania. Brown has been associated with U. S. Rubber since 1945. He is a graduate of Syracuse.

J. S. Baker, assistant district manager at Pittsburgh, moves up to district manager, and **W. L. Anderson** becomes the new district manager at Omaha, Nebraska. Anderson succeeds **D. A. Buchanan,** who will have a special assignment in the truck tire department.

Ted C. Bauck has been appointed as a Gorman-Rupp district representative, covering a five state mid-western area. A graduate of Tri-State College, Bauck was formerly with Goulds Pump, Inc.

Donald L. Sanders has been named district representative for Ohio, West Virginia, Pennsylvania, New York and parts of Kentucky. Sanders was with Clayton Manufacturing as district manager of a four state area and as a sales engineer. He attended the Findlay School of Engineering at Kansas City, Missouri.

Richard M. Fraser is the district representative for Northeastern United States. Fraser has had 15 years experience in pump sales. He was formerly with Marlow Pumps, division of Bell and Gossett, and Yale and Towne Pumps, Inc.

Jack E. Heuser has been appointed vice president in charge of sales for the Le Roi Company. An engineering graduate of the University of Wisconsin, Heuser joined Le Roi in 1939. In 1941 he became a member of the Ampco Metal sales organization. In 1946 he rejoined Le Roi as assistant to the general sales manager and was later promoted to engine division sales manager.

Ray H. Rodolf has been appointed general manager of the compressor division. **Herschel V. Hiatt** has been made general manager of the engine division. Rodolf was former sales manager, construction and mining division. He served in that position for the past year. Hiatt joined Le Roi almost a year ago as director of engineering.

Marvin M. Ramer has been appointed manager of sales promotion of Blaw-Knox Company's chemical plants division. Ramer was formerly contract manager of the division's western headquarters at Tulsa, Oklahoma. He is a graduate in chemical engineering from Rensselaer Polytechnic Institute.

J. J. Neale

R. S. Durkee

John J. Neale has been named president, **Rodney S. Durkee,** chairman of the board, and **Walter T. Wells,** founder-chairman of Lane-Wells Company. Neale was also made a director.

Neale, who has been assistant to the president for the past year joined the company as a loader in Houston, Texas in 1936. He is a graduate of Texas A and M. Durkee joined Lane-Wells in 1938 as executive vice president. He was made president in 1939. Wells the co-founder of the company in 1932. He was president until 1939 and has been chairman of the board until the present.

Oliver J. Guseman has been appointed assistant Gulf Coast division operating superintendent. **John C. Wilson** has been named assistant Gulf Coast division radioactivity engineer. **Courtney J. Ritchie** has been appointed district sales engineer at Gainesville, Texas. **Norman C. Jones** has been appointed Mid-Continent division field engineer and transferred to Oklahoma City. **Sammie N. Conley** has been appointed a district sales engineer trainee in the Rocky Mountain district at Newcastle, Wyoming.

Jimmy L. Baker has been named district sales engineer at Duncan, Oklahoma. **Glenn E. Cooper** has been appointed subdistrict superintendent at Russell, Kansas. **Jennings B. Thompson** has been appointed station superintendent at Stockton, Kansas.

Ahlborn Wheeler has joined the research staff of Houdry Process Corporation. As a member of the fundamental research division, Wheeler will study the catalytic activation of hydrogen. A graduate of Princeton University, Wheeler formerly worked for Shell Development Company. Since 1946 he has been with the polychemicals department of Dupont.

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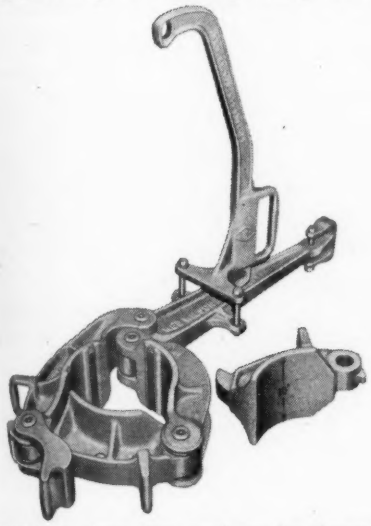
- Supplies
- Services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(1) CASING TONG

Web Wilson's new "deep face" casing tong (Type ADF) is said to handle the lightest weight casing without danger of bottlenecking or crushing. Tong has a



full 10-in.-deep face, and can be changed from one size to another by changing only one jaw. Only 5 interchangeable lug jaws are needed to fit all casing sizes from 9⅝ to 17 in. OD, and each lug jaw fits both the casing and the coupling of a given size.

Circle number (1) on reply card.

(2) QUADRANT ORIFICE PLATE

The Taylor Instrument Companies have added a Quadrant Orifice Plate to their complete line of flow measuring elements. This new orifice utilizes the result of extensive research done primarily in Europe in the development of an orifice type element designed to measure flows of liquids under varying viscosity conditions.

Circle number (2) on reply card.

(3) CLUTCH

A new development for the 26.8 hp Kohler K660 air-cooled engine is a hand clutch, according to sales officials of Kohler Company. The wet type, lever operated clutch, designed to engage at all engine speeds, is mounted on anti-friction ball bearings.

Circle number (3) on reply card.

(4) HEATER

A electric heater which makes use of copper sheathed, mineral insulated, resistance cable has been recently developed and placed on the market by Nelson Electric Manufacturing Company. Designed to operate at temperatures up to 500 F in open air, working temperatures of 1000 F can be tolerated when the heater is immersed in liquids to exclude oxygen. Heater can be immersed in any liquid not harmful to copper or it may be imbedded in concrete or earth.

Circle number (4) on reply card.

(5) DRILLING RIG

A new rig for 3500 ft to 6000 ft drilling, with 4½-in. drill pipe, has just been introduced by Oil Well Supply Division, United States Steel Corporation. Known as the No. 52-T, this new rig boasts all the functional and structural features which have long been available in the other rigs in "Oilwell's" line.

Circle number (5) on reply card.

(6) DITCHER

A crawler-mounted service utility and foundation ditcher has been announced by Gar Wood Industries. The ditcher, Gar Wood Buckeye model 403, is a small, easy-to-maneuver ladder-type ditcher easily transported from job to job. Capacity of ditcher is 5 ft deep for 8, 10, and 12-in. widths of cut and 4 ft deep for 14 and 16-in. widths of cut.

Circle number (6) on reply card.

(7) SWIVEL

S. R. Bowden Company has announced its Type D Bowen powered swivel. This its new unit develops a speed of 80 rpm in high gear and a speed of 40 rpm in low gear—an increase in speed of more than 85 per cent over the speed developed by the Type C Bowen powered swivel and more than double that of any other unit of this type now on the market. The S. R. Bowen Company now offers to the trade 3 sizes of Bowen powered swivels—the Type B, the Type C and the Type D. All of these powered swivels are available either as skid mounted units or as trailer mounted units.

Circle number (7) on reply card.

(8) AIR-COOLED ENGINE

A new development in the Kohler air-cooled engine line is Model K90R, according to Kohler Company sales officials. Engine is equipped with a reduction unit providing a 6:1 gear ratio for applications requiring low power take-off speeds. The K90R, rated at 3.6 hp, weighs only 52 lb and includes such outstanding features as an oil bath air-cleaner, a fly-ball governor, and a ball bearing mounted crankshaft.

Circle number (8) on reply card.

(9) CROWN BLOCK

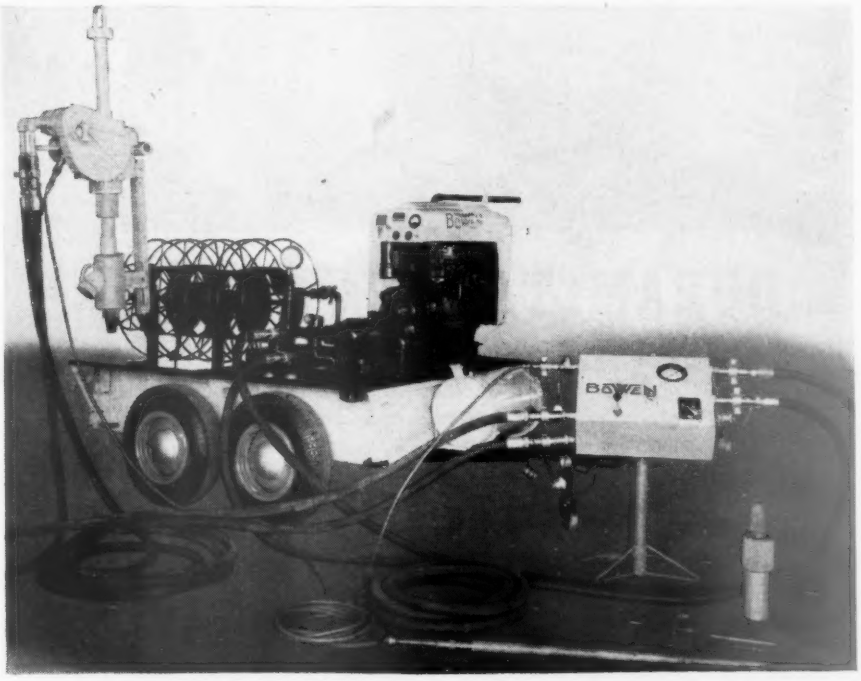
IDECO has announced a new 400-ton crown block — a companion to the 400-ton "Big Shorty" traveling block with sheaves and bearings completely interchangeable. The new 400-ton series crown block can be furnished as either a 6 or 7-sheave block having 50 or 60-in. diameter sheaves. An option of 1¼, 1⅜ or 1½-in. groove-size is offered. Weights vary from 6835 to 8300 lb in the series depending on the number and diameter of sheaves.

Circle number (9) on reply card.

(10) MULTIVALVES

An all-new greatly expanded line of anhydrous ammonia control equipment has recently been introduced by The Bastian-Blessing Company. Equipment was specifically designed and engineered for NH_3 service. Main feature of the new RegO line is its A7506 Series Multivalve Assemblies designed for use on field storage tanks and applicator tanks.

Circle number (10) on reply card.



S. R. Bowden Company's Type D Bowen powered swivel.

NICHOLSON TRAPS

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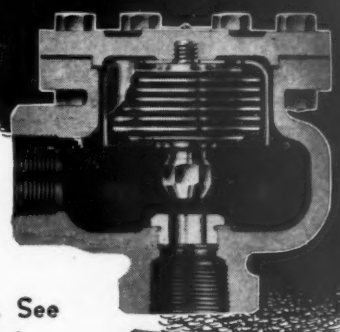

Send for Nicholson catalog 953. This 32-page standard reference on advance-type trapping of steam, air and other mediums contains: installation diagrams, charts for determining trap sizes, and advice on specific problems. See why leading plants are increasingly standardizing on Nicholson traps for increased production and minimum maintenance: thermostatic (illustrated) and metal expansion for pressures to 250 lbs.; weight and piston-operated, to 1500 lbs.

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New Equipment

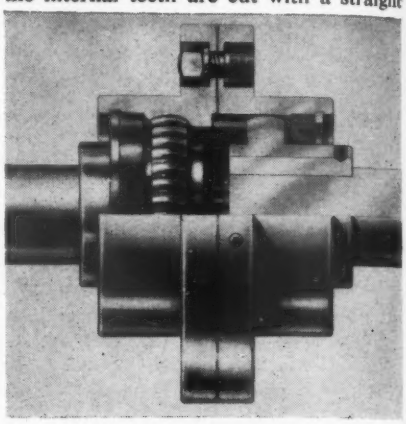
(11) CYLINDER HEAD

The new industrial engine department of Willys Motors, Inc. has introduced a 4-cylinder "F" head design for more widespread use in industrial, agricultural, construction and marine equipment. Bore and stroke of Model 4F is 3⅛ in. by 4⅜ in. and the total piston displacement is 134.2 cu in. Maximum brake hp at 2400 rpm is 51 hp and at 4000 rpm is 70 hp. Compression ratio on Model 4F is 6.9 or 7.4.

Circle number (11) on reply card.

(12) COUPLING

The Philadelphia Gear Works is offering industry a Sphereflex coupling having gear teeth that are cut on a segment of a a sphere. The male teeth of each coupling half are cut on a true spherical arc while the internal teeth are cut with a straight



root. Thus, whenever misalignment occurs, the curved tooth maintains a contant area of contact with the internal tooth. The standard coupling is suitable for angular misalignments up to plus or minus 3½ deg on each coupling half, giving a total of plus or minus 7 deg for the standard coupling. Special couplings are available, suitable for 14 deg misalignment.

Circle number (12) on reply card.

(13) PUMPING STARTER

An oil-well pumping starter featuring a gasketed enclosure and ventilated overload relay compartment has been announced by the general purpose control department of the General Electric Company. The starter enclosure is sealed with a neoprene gasket to prevent entrance of dust or rain, but at the same time, a separate ventilated overload relay compartment helps prevent relays from tripping due to heat from the sun. An external reset button permits resetting relays without opening the sealed main starter enclosure.

Circle number (13) on reply card.

(14) MONITOR

A pipe line bearing monitor called "Simplytrol Polypoint" has been developed by Assembly Products, Inc. Product monitors all critical bearings in pipe line pumping stations and shuts down the station in case of temperature rise. Temperatures are shown directly on the Simplytrol meter scale. The safety trip point is set just above the normal operating temperatures. Contacts in the Simplytrol meter-relay close in case of temperature rise and shut down the station. Other controls manipulate valves to immediately bypass this station. The shutdown is signaled to a central control station.

Circle number (14) on reply card.

(15) ROLLER BEARINGS

High speed and intermediate shafts of Herringbone gear reducers manufactured by W. A. Jones Foundry and Machine Company are equipped with Rollway cylindrical roller bearings of the precision type (MCS). Depending upon the size of the speed reducer, shaft bearing surfaces range up to 6.690-in. in diameter. Supporting radial loads only, MCS roller bearings with 6.6929-in. bore, 10.4331 in. OD and 3-in. width have a rated load capacity of 119,175 lb at 25 rpm and 34,925 lb at 1000 rpm.

Circle number (15) on reply card.

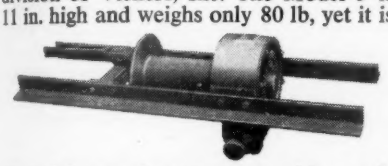
(16) TURBINE REGULATORS

Designed for boiler feedwater applications requiring precise automatic control of water pressure, pressure regulators can be used with any Dean Hill Pump Company turbine model of either horizontal or vertical design. They are furnished with direct-acting or remote control, and can be arranged to maintain a constant pump discharge pressure or a constant differential pressure over boiler pressure.

Circle number (16) on reply card.

(17) WINCH

A lightweight winch has been added to the line manufactured by Tulsa Winch, division of Vickers, Inc. The Model 5 is 11 in. high and weighs only 80 lb, yet it is



powerful enough to operate with a safe working load of 6000 lb. Winch has a high worm gear ratio (60 to 1) which permits direct drive from the source of power and eliminates the need for a worm brake. It can be installed in any convenient location.

Circle number (17) on reply card.

(18) FLOTATION UNIT

Graver Water Conditioning Company has announced a new flotation unit, known as the Graver Aeroflotor. Besides handling floatable particles, the unit is capable, when necessary, of also removing settleable particles at the same time in the same unit. Unit can be especially advantageous where both heavy and light density are to be removed from the same liquid.

Circle number (18) on reply card.

(19) ELECTRODE

Aluminum Company of America has developed a new high quality welding electrode. The new electrode is currently being produced from 3 aluminum alloys —2S, 43S, and A54S. It is packaged and stocked on non-returnable fiber spools in the following wire sizes: .030 in., 040 in., 3/64 in., 1/16 in., 3/32 in., and ⅛-in. diameters.

Circle number (19) on reply card.

(20) TRENCHLINER

Hydraulic control of the digging wheel is an important feature on the new 150 wheel-type trenchliner developed by the Parsons Company. Trenchliner produces from 12 in. to 25 lineal feet of trench per minute. It has a digging capacity of 5¾ ft deep and 16 to 26 in. wide. The Model 150 is equipped with a range of 30 digging feeds, and 3 speeds on the heavy-duty digging wheel up to 11.25 rpm.

Circle number (20) on reply card.

(21) MOTOR BASE

T. B. Wood's Sons Company has designed and is now manufacturing its "Quick-Slide" motor base. Unique feature of the "Quck-Slide" motor base lies in the provision for releasing the adjusting screw, which permits the motor to be moved freely and quickly.

Circle number (21) on reply card.

(22) SHOVEL-CRANE

The LS-68, a light ¾-yard shovel-crane, has been announced by Link-Belt Speeder Corporation. Machine takes the place of the LS-52. The LS-68 offers all advanced features, including Speed-o-Matic power hydraulic controls, with several notable advancements added.

Circle number (22) on reply card.

(23) LIQUID CONTROLLER

Black, Sivalls and Bryson, Inc., has introduced its Type 1450 pilot for displacement type liquid level controllers, where a torsion tube transmits float movements to reflect changes in liquid level or a change in gravity of the controlled fluid.

Circle number (23) on reply card.

(24) TRUCK

A powerful, new, extra-heavy-duty, 6-wheel truck model, the International RF-230 has been placed in production by the motor truck division of International Harvester Company. The new model, with gross vehicle weight rating of 60,000 lb, is powered by the new 201-hp International RD-501 engine.

Circle number (24) on reply card.

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New Equipment

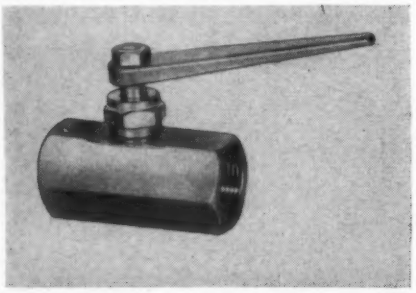
(25) ENCIRCLEMENT SADDLE

A recently developed Tube-Turn full encirclement saddle is said to be a marked improvement over the conventional saddles employed in the "hot tapping" of petroleum piping, when branch connections are to be installed. Saddle is designed for use with either high yield strength thin wall pipe, Grade B 35,000 or 42,000 yield strength pipe. It is available in standard and special sizes through 42 in., and in all straight and standard reducing outlet sizes.

Circle number (25) on reply card.

(26) VALVE

The Jamesbury Corporation has developed a double-seal ball valve. The valve is produced in aluminum, brass, bronze,



monel, stainless, carbon steel, and other wrought alloys, with seats and packings in Buna-N, Neoprene, Silicone, Teflon, and Kel-F. Manufacturer claims to be able to handle a wider scope of liquids and gases than any other valve line. Valve comes in sizes from ¼ in. to 2 in.

Circle number (26) on reply card.

(27) TACHOMETER GENERATOR

A low-cost d-c tachometer generator, designed for a variety of control applications, as well as for accurate speed indications, has been announced by the General Electric Company's instrument department. The generator provides an unusually high voltage output of 50v/1000 rpm for speeds up to 5000 rpm, and 100v/1000 rpm for speeds up to 2500 rpm, and is an ideal pilot exciter for many control applications, according to company engineers.

Circle number (27) on reply card.

(28) SILICA

"Silica soot," an almost chemically pure silicon dioxide with a particle size of only 10 to 20 millimicrons, is now being manufactured semi-commercially for the first time in this country by Dow Corning Corporation. Product can be used as a reinforcing filler for synthetic rubbers and plastics, a flatting agent and extender for protective coatings, a thickener for lubricating greases, and as an additive in textile finishing.

Circle number (28) on reply card.

(29) FLANGE PROTECTOR

A flange protector which forms a protective seal against corrosive elements and offers a number of other advantages has been introduced by Oil Center Tool Company. Protector can be applied between any two flange segments on Christmas trees eliminating outer ring guards. No maintenance or lubricants are required after the protector is installed. It is simple to install and durable for permanent protection. The flange protector is made of Hycar and is available in a complete range of sizes through 16-in. Series 900.

Circle number (29) on reply card.

(30) PIPE LINE WRAPPER

"Dura-Tape" a cold application pipe line wrapper with a built in primer has been developed and placed on the market by the Dura-Tape Company. Dura-Tape can be applied under any weather conditions, and two or three unskilled employees can wrap from ½ to 1 mile of pipe per day and leave it in the ditch ready for back-fill. Primer is non-drying and Dura-Tape will stand 10,000 to 15,000-v imposed by a Holiday tester.

Circle number (30) on reply card.

(31) RECIPROCATING PUMP

A high-pressure, low-volume reciprocating pump has been added to the line manufactured by Frank Wheatley Pump and Valve Manufacturer. The Figure 333 pump will deliver from 15 bph at 1000 psi (with 1¾-in. liners) to 50 bph at 340 psi (with 3-in. liners) when operating at 1000 rpm and requires 7½ hp. A complete selection of liners is available to give many intermediate volume-pressure ratios within this range.

Circle number (31) on reply card.

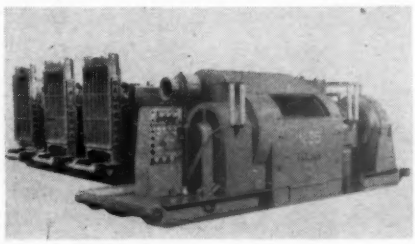
(32) SHINGLES

A unique roofing development is being produced by The Ruberoid Company. It is an interlocking, asphalt strip shingle which looks like the square tab but is said to be actually capable of shrugging off a hurricane. The center of each butt on the strip has a hook-shaped extension which is an integral part of the shingle. This fits snugly into a precut slot in the body of the shingle below. As each course is applied, the locking device is hidden from view so that a completed roof appears to be covered with conventional asphalt square tabs.

Circle number (32) on reply card.

(33) DRAW WORKS

Already in the field making hole, the Brewster 1200 hp N-95 offers 14,000-ft drilling with a draw works that can be moved as a single package. Controls,



transmission, rotary drive, and hydromatic brake are all mounted on the main skid. Available in a wide selection of horsepower combinations and a choice of direct mechanical, fluid coupling or torque converter drive arrangements, the N-95 maintains economy of operation and maximum efficiency over a wide drilling range—8000 to 14,000 ft.

Circle number (33) on reply card.

(34) BEARINGS

The Link-Belt Company line of "Mill Bearings" has been augmented to include pillow blocks with heavy-duty self-aligning roller bearings for press fit on shafts. In common with other Link-Belt "Mill Bearings," the new series LPK7800F bearings have steel split housings. The extremely rugged caps and bases are secured with four extra-heavy bolts and large dowels. The bearings are available in bore size range of 3.1496 in. to 7.4803 in.

Circle number (34) on reply card.

(35) VOLT-AMMETER

A wide range pocket size volt-ammeter for measuring alternating current and voltage quickly and accurately has been introduced by the General Electric Company's instrument department. Measuring only 9⅛ in. by 3 7/16 in. by 1 9/16 in., the product is designated AK-4, and includes 150/300/750 volts AC as its volt ranges, according to G-E engineers.

Circle number (35) on reply card.

(36) DUAL VALVE

McEvoy Company has announced its dual-valve—two valves in one for dual completion with two full size tubing strings. Valve is to be used principally in

the building of trees for production from two or three formations, saving the cost of drilling a second well. The two tubing bores plus the casing annulus can be used as separate and individual passageways for many combinations of flowing, pumping and/or gas lifting.

Circle number (36) on reply card.

(37) LEVEL CONTROLLER

Jarco Services Inc's Prob-A-Larm level control uses bridge circuit to give extreme dependability in capacitance relay circuit. No coax cable is required and probe may be located as far as 500 ft from the main unit. Instrument works with almost any material-liquid, powder, or in chunks to give an electrical signal for control or alarm when material gets to probe in vessel.

Circle number (37) on reply card.

(38) PERFORATOR GUN

A shaped-charge, 4-way perforator designed to increase the chances of success of squeeze cementing operations has been introduced by Lane-Wells Company. The Koneshot gun was developed to provide the optimum number of perforations in the same horizontal plane, and by providing the minimum vertical distance between shot groups, to concentrate cement pressure against bedding planes and thin strata.

Circle number (38) on reply card.

(39) COMPUTER

A new instrument, designed to meet the needs of intricate applications where close computing accuracy is required, has been developed by the Taylor Instrument Companies. Called the Transet Computing Relay, it is capable of adding, subtracting, averaging, and ratioing.

Circle number (39) on reply card.

(40) PRESSURE CONTROLLER

Black, Sivalls and Bryson, Inc., has introduced its Type 1440 pressure controller (non-recording) for sensitive pressure-vacuum control systems. Controller is designed to handle both positive and negative pressures, from high vacuum to pressures up to 10,000 lb.

Circle number (40) on reply card.

NEW oil and gas Literature

- Brochures
- Bulletins
- Catalogs

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(41) CHAINS, SPROCKETS

Stock Roller Chain and Sprockets is the title of Catalog 754, a 64-page illustrated book published by Diamond Chain Company, Inc. Catalog 754 covers a complete line of roller chain stock sprockets. Line includes minimum bore sprockets for reboring as well as finished bore and Taper-lock bushed sprockets which are ready to use.

Circle number (41) on reply card.

(42) TRACTOR COMPRESSOR

A new bulletin on the Le Roi 600 CTM (compressor tractor mounted) has been released by the Le Roi Company. The 2-page piece of literature contains views of the 600 CTM mounted on a Caterpillar D 8, a International Harvester TD 24, and show it unmounted without the protective tubular steel frame.

Circle number (42) on reply card.

(43) FLEXIBLE FLOW LINES

A comprehensive 12-page illustrated catalog released by OPW Corporation gives general information and detailed specifications on 35 styles of bronze and steel, plain and flanged swing joints. Recommendations and information on use, care and maintenance of equipment are enclosed.

Circle number (43) on reply card.

(44) SENSATOR

Martin-Decker has released a four-page folder illustrating its E-80 Sensator and weight indicators. Folder contains photographs of the new product and charts showing how the sensator, with weight indicators, will fit any drilling job. Principal of the Sensator is fully explained in the folder.

Circle number (44) on reply card.

(45) POWER TAKE-OFF

Publication of bulletin No. 506, describing the performance of, and giving complete engineering data on Twin Disc Disconnecting Fluid Power Take-Off Model 21 HUD-0, and Model 27 HUD-00 is announced by the Twin Disc Clutch Company. Bulletin No. 506 gives performance and capacity charts; and actual applications that have been solved with the installation of a Model HUD Disconnecting Fluid Power Take-Off.

Circle number (45) on reply card.

(46) DUCTILE CAST IRON

International Nickel Company has issued bulletin DI-2 containing engineering applications of ductile cast iron. The 8-page bulletin presents data on machinability, gall resistance, compressive strength, and other mechanical properties of this recently developed family of irons which possesses the process advantages of cast iron and which has engineering properties that approach those of cast steel.

Circle number (46) on reply card.

(47) CONDENSER TUBE DATA

Availability of an engineering condenser tube data book, "An Opportunity to Cut Costs and Increase Capacity with Wolverine Trufin," has been announced by Wolverine Tube, division of Calumet and Hecla, Inc. Book contains complete engineering data on Trufin type S/T extended surface condenser tube for shell and tube heat exchangers. Engineering data consists of results on field installations, correlated in conjunction with findings obtained in controlled laboratory tests.

Circle number (47) on reply card.

(48) COATING

A condensed, revised catalog of Magic Chemical Company products has been issued. Prepared in easy-to-read outline form, the catalog contains important facts about protective coatings and their many industrial applications. The use of MAGIC-VULC to protect industrial equipment from corrosion and abrasion is fully described.

Circle number (48) on reply card.

(49) HYDRAULIC PUMP

The Aldrich air driven hydraulic pump is described fully in data sheet 36, published by The Aldrich Pump Company. Material includes complete information on design, installation and operation, and is illustrated by photographs and sectional and dimensional drawings.

Circle number (49) on reply card.

(50) TELEMETERING

Minneapolis-Honeywell Regulator Company's instrumentation data sheet No. 9.1-9a describes improved electric telemetering equipment for high speed transmission of system variables to a central location. Details are given on how ElectroniK indicating, recording and totalizing instruments can be incorporated at various points in the system.

Circle number (50) on reply card.

(51) CRAWLER TRACTOR

An 8-page booklet depicting improved methods of crawler tractor manufacturing over the last 50 years has been released by Caterpillar Tractor Company. The illustrated booklet, form No. D438, written in conjunction with the fiftieth anniversary of the crawler tractor, gives a brief history of track type tractor manufacture beginning with the building of the first practical crawler 50 years ago.

Circle number (51) on reply card.

(52) TRAILER

Athey Products Corporation has released a 4-page booklet on its new trailer. Construction, features, specifications, and applications are described in the folder. Method of converting the trailer for specific uses is also illustrated in the booklet.

Circle number (52) on reply card.

(53) PERISCOPES

Kollmorgen Optical Corporation has published a 4-page bulletin on industrial periscopes. Bulletin 301 covers construction of typical periscopes, steps necessary in planning for an industrial periscope, and data needed when ordering.

Circle number (53) on reply card.

(54) TANK DATA BOOK

Hammond Iron Works has released catalog 54B, latest of its data books dealing with storage tanks and steel plate fabrication, features material specifications, tank design data, foundation recommendations, accessories and fittings, computing tables for size and capacity, welding procedures, testing methods, and information on all types of storage tanks and general steel plate construction.

Circle number (54) on reply card.

(55) CLAMPS

Thomas Associates has released engineering manual 2016 covering complete design data of the types of clamps and related items manufactured by the company. The 60-page manual contains diagrams showing how clamps are used.

Circle number (55) on reply card.

(56) STEEL

United States Steel Corporation has released a special bulletin on a new steel called USS Carilloy T-1. Product is said to combine the unusual attributes of high strength, unusual toughness, good weldability, and excellent resistance to impact abrasion at temperatures from —150 F to as high as 900 F.

Circle number (56) on reply card.

(57) SWIVEL JOINTS

Chiksan Company has issued a new 32-page catalog, G-4, which covers the complete line of Chiksan ball-bearing swivel joints and other products, including loading racks, manifolding lines, all-metal marine and barge hose, and flexible aircraft assemblies.

Circle number (57) on reply card.

(58) STEAM GENERATOR

Bulletin MSG-1 covering Vogt multi-stream steam generators has been released by Henry Vogt Machine Company. The four-page bulletin contains photographs and illustrations of the different type generators.

Circle number (58) on reply card.

(59) MORPHOLINE

A technical bulletin on morpholine has just been issued by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation. Information on properties, specifications, shipping data, and safe handling practices is given with suggested applications and a selection of literature references.

Circle number (59) on reply card.

Trade Literature

(60) SLIP CASING HANGERS

McEvoy Company has recently printed an eight-page brochure outlining its "Controlled Friction" principle which eliminates dangerous pipe bottle-necking. McEvoy's slip casing hangers enables hanging any weight of pipe in the world's deepest wells economically, dependably, and quickly.

Circle number (60) on reply card.

(61) CATHODIC PROTECTION

A new booklet covering the "whys" and "hows" of cathodic protection is announced by National Carbon Company, a division of Union Carbide and Carbon Corporation. The 12-page catalog section is a complete reference work on the mitigation of corrosion of underground and submerged metal structures by the application of an impressed current cathodic protection system using "National" graphite anodes. Booklet also contains valuable information on the cost of corrosion; the economics of cathodic protection; where and when it can and should be applied; facts about impressed current systems and how they should be installed.

Circle number (61) on reply card.

(62) DUCTILE IRON

The International Nickel Company, Inc., has released bulletin DI-5 on the machinability and productivity of ductile iron. The 5-page bulletin contains tables, charts, and plotted data showing characteristics of grades of ductile iron.

Circle number (62) on reply card.

(63) VALVE CONTROLS

Philadelphia Gear Works has announced a complete 21-page catalog, L-54, describing "LimiTorque" valve operators. Catalog illustrates and describes the latest LimiTorque SMA valve control for large or small valves, as well as showing operational details and illustrations.

Circle number (63) on reply card.

(64) V-BELT DRIVE

Worthington Corporation has prepared a series of five easy-to-file self-mailers called "Trouble Savers" which are intended to help the users of V-Belt Drive diagnose many of the common causes of trouble in their drives. Mailer V-1400-M-39, first in this series, explains what to look for when the V-Belt Drive doesn't deliver maximum rpm.

Circle number (64) on reply card.

(65) PACKING AND GASKETS

"Chempac Packings and Gaskets" is the title of a six-page, illustrated folder issued by Johns-Manville. The folder gives pertinent information on each of the several types. These include Chempac Interlocked Packings, Chempac Packings in coil, spiral and ring forms which are offered in four styles, general purpose Chempac Gaskets offered in two syles, Chempac Folded Gaskets for glass lined equipment offered in two styles, and Chempac Spirotallic Flange Gaskets for high pressure service.

Circle number (65) on reply card.

(66) PRESSURE INSTRUMENTS

A completely new line of pressure measuring elements with greater operating power and improved accuracy are graphically described in bulletin 6-10, "Pressure Recorders," issued by The Foxboro Company. The 24-page publication explains the company's line of pressure instruments designed for direct measurement, remote transmission and automatic control, and widely used in instrumenting the more specialized processes of industry.

Circle number (66) on reply card.

(67) PUMPS

A catalog on industrial centrifugal pumps is available from Eastern Industries, Inc. The 12-page catalog offers helpful engineering data: It has specifications on all models, performance diagrams, dimensional drawings, instructions on stuffing boxes, and mounting diagrams.

Circle number (67) on reply card.

(68) WELDING EQUIPMENT

A new condensed 52-page catalog, ADC-662B, that describes and illustrates all of the Airco products is being offered by Air Reduction. Catalog covers Airco gases, welding and cutting equipment and accessories—torches, tips, regulators, electrodes, etc.

Circle number (68) on reply card.

(69) ELECTRIC EQUIPMENT

Bulletin GED-1966A, Electric Equipment For Process Industries, has been announced as available from the General Electric Company. The 28-page publication provides detailed information on G-E electrical equipment for power generation, power distribution and conversion, power utilization, instrumentation, descriptive publication, and G-E service shops and warehouses.

Circle number (69) on reply card.

WHEELING
COUPLINGS
FOR OIL COUNTRY USE
LINE PIPE COUPLINGS A.P.I.
1/8" to 12" — Seamless and Special Processed — Black or Galvanized
PLAIN TUBING COUPLINGS A.P.I.
1" to 2" — Seamless
EXTERNAL UPSET TUBING COUPLINGS A.P.I.
3/4" to 3 1/2" — Seamless
CASING COUPLINGS A.P.I.
4 1/2" to 13 3/8" — Long or Short
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1/8" to 4" — Seamless
REAMED AND DRIFTED A.I.S.I.
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DRIVE PIPE COUPLINGS
3/8" to 12" — Seamless or Special Processed
TOP QUALITY Since 1918
Sales Offices in Leading Cities:
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WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA.
and WOODLAKE, CALIFORNIA

Trade Literature

(70) TANK HEATER

A 4-page bulletin No. 541 released by Brown Fintube Company describes its "TF-18" tank heater that mounts vertically, preventing sediment from settling on the heating surface—avoids heating through a layer of sediment—leaves the bottom of the tank uncluttered and easy to clean. Said to provide more efficient, less costly tank heating than old fashioned bottom coils. Can be installed quickly and inexpensively in new or existing tanks without requiring welding in the tank.

Circle number (70) on reply card.

(71) REFORMER

Koppers Company, Inc., has released a bulletin describing the Kopper-Hasche reformer. Reformer is said to be a high efficiency unit producing low cost gas; low in capital investment cost; available in a compact package unit, and adaptable for either base load production or peak. It is also said to produce gases of relatively low gravity interchangeable with most manufactured and natural gases.

Circle number (71) on reply card.

(72) RUBBER PRODUCTS

The PB division of Byron Jackson Company announces the availability of a 52-page, 2-color catalog illustrating and describing the complete line of PB oilfield rubber products. More than 30 different product categories and several hundred models are listed, including drill pipe protectors and stabilizers, pipe wipers, wire line guides, bumpers, mud equipment, and other oilfield specialties. Charts are included that provide for the selection of protectors or stabilizers.

Circle number (72) on reply card.

HOSPITALITY AT ITS BEST IN HOUSTON

One thousand air-conditioned rooms... four great restaurants... 1,000-car garage ...ideal entertainment and convention facilities. Rates from $4.50 single and $6.50 double.

B. F. ORR, *Management*

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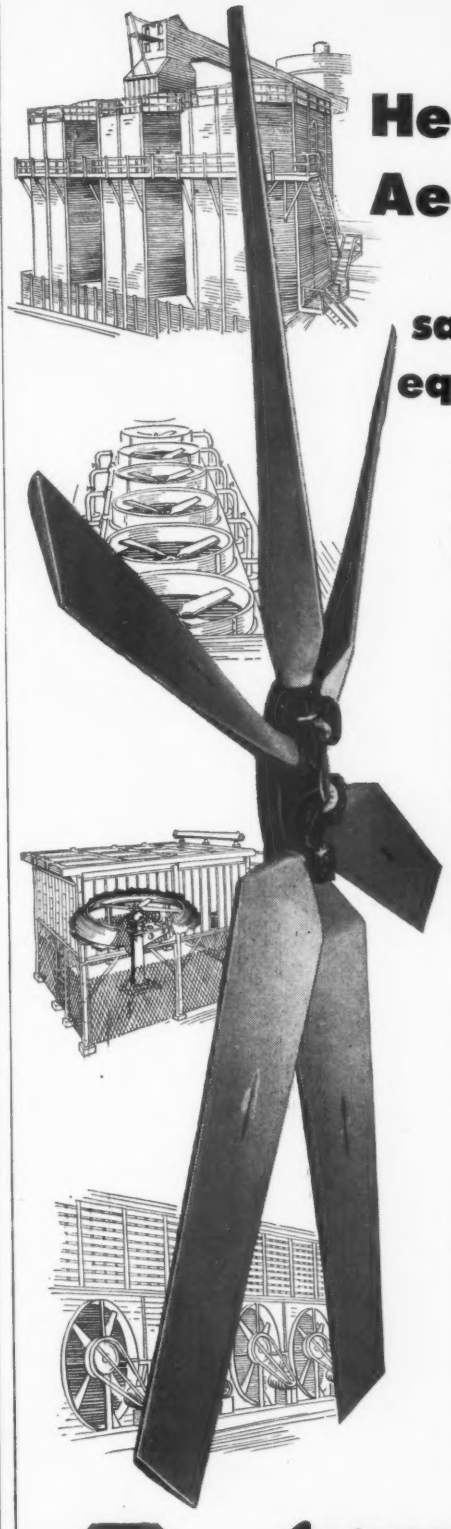
HOUSTON, TEXAS

Home of the fabulous Petroleum Club



Here's Why Aeromaster Fans mean more satisfactory cooling equipment operation

Manufacturers and users of cooling equipment agree... Aeromaster Fans give outstanding service. Here are the reasons why.

Aeromaster Fans are *precision engineered,* adapted from high speed aircraft propellers. They have adjustable blade pitch and anti-flutter design . . . therefore, require less horsepower. And they last longer too, thanks to the exclusive Aeroloid blade coating to resist acids and alkalies, abrasion and weather. Overall result: Aeromaster Fans *give more cooling at lower cost.*

Available in 4, 6, or 8 blade styles, in diameters of 5 to 24 ft., with capacities up to 1,000,000 cubic feet per minute, all Aeromaster Fans are fully guaranteed.

Koppers also has trained engineering specialists available in principal cities, insuring prompt, expert Aeromaster Fan service. And Koppers is always ready to consult with you on special fan problems. Next time you plan a replacement of present fans, specify Aeromaster. And when you consider new equipment, call on Koppers . . . always eager to be of service.

KOPPERS

Aeromaster Fans

METAL PRODUCTS DIV. • KOPPERS COMPANY, INC. • BALTIMORE, MD. • This Koppers Division also supplies industry with Fast's Couplings, American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators and Gas Apparatus. *Engineered* Products Sold with *Service*

MAIL COUPON TODAY FOR COMPLETE INFORMATION

KOPPERS COMPANY, INC., *Aeromaster Fans,* 320 Scott St., Baltimore 3, Md.

Gentlemen: Please send me detailed information on Aeromaster Fans for

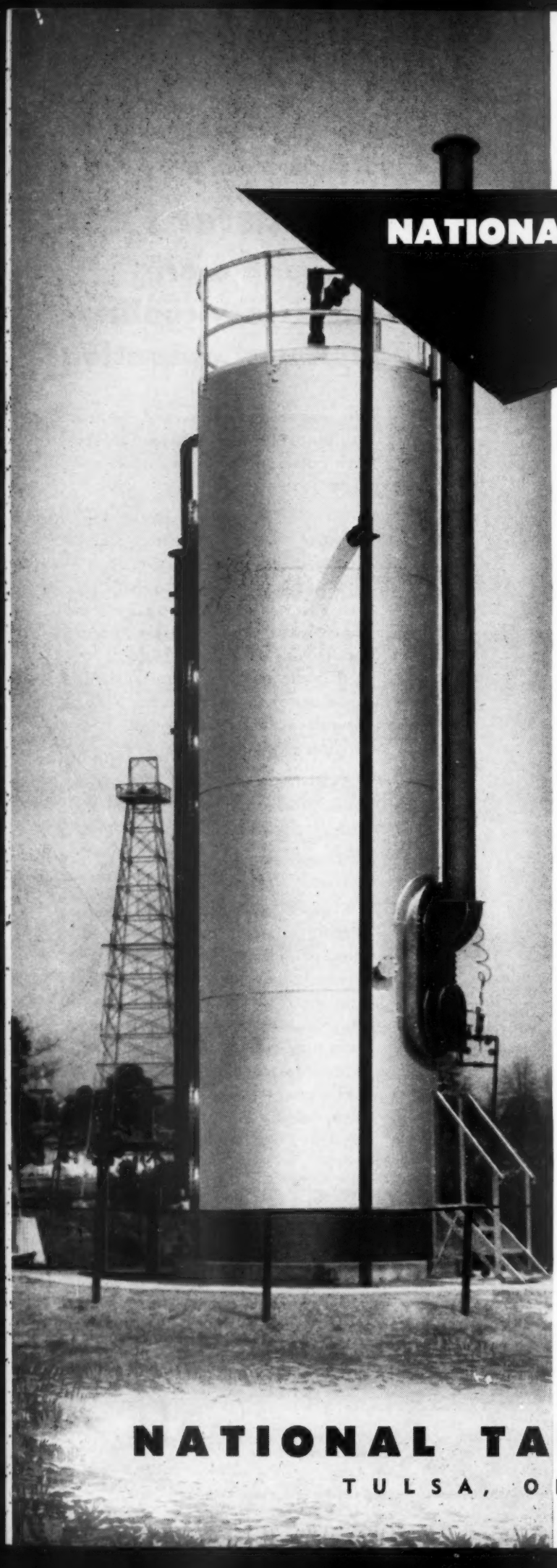
_____
(name and type of equipment to be cooled)

Name _____

Title _____ Company _____

Address _____

City _____ Zone _____ State _____



NATIONAL ICP TREATER . . .

SAVES
$731.64 PER MONTH

Inter-Office Correspondence

To: [redacted] Date: April [redacted]

Subject: National ICP Treater
installed on our [redacted] Lease.

Dear Bud:

We thought you might be interested to know of the results obtained from the installation of the ICP Treater on our [redacted] Lease last September.

In figuring the amount of gas purchased for this lease, taking months comparable in weather conditions, six months before and six months after the installation, we find that in the preceding six months we bought gas in the amount of $1,298.99 and in the succeeding six months we purchased gas in the amount of $599.47 a total saving for six months of approximately $699.47 or $133.00 per month.

Before installing this Treater it was necessary that we clean ten tanks per month, losing approximately twenty barrels of oil each time. This would amount to 200 barrels per month or approximately $486.00 per month. This Treater has now been in service approximately eight months and we have not cleaned a single tank.

In addition to the gas and tank cleaning saving we also raised the gravity of the oil an average of 1°, which raised the price of the oil .02¢ per barrel. As this lease averaged 5,632 barrels of oil per month after installation of the Treater the amount gained on raising the gravity amounted to $112.64 per month.

We figure the total savings as follows:

$133.00 per month saving on gas.
$486.00 worth of oil saved each month.
$112.64 more per month for increased gravity.
$731.64 Total saving each month.

The first six months after installing this Treater we had saved $4,395.84. As the Treater cost $3,439.26, at the expiration of six months the Treater was paid for with $956.58 left over as profit.

Respectfully yours,

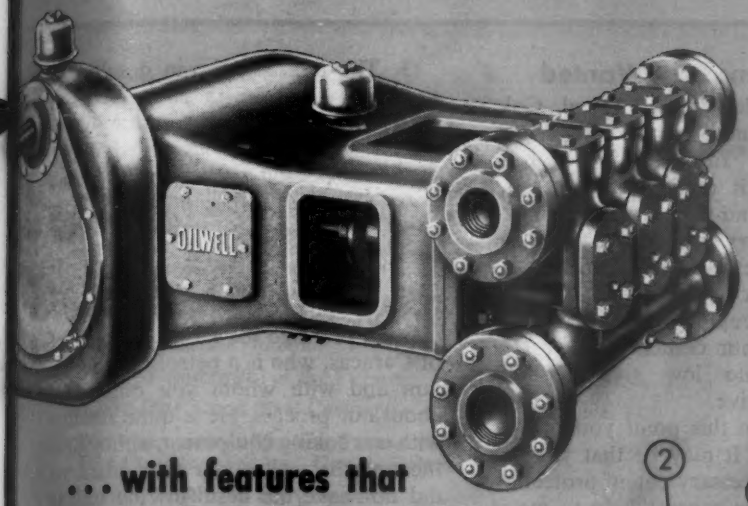
[redacted]

It's a National

NATIONAL TANK COMPANY

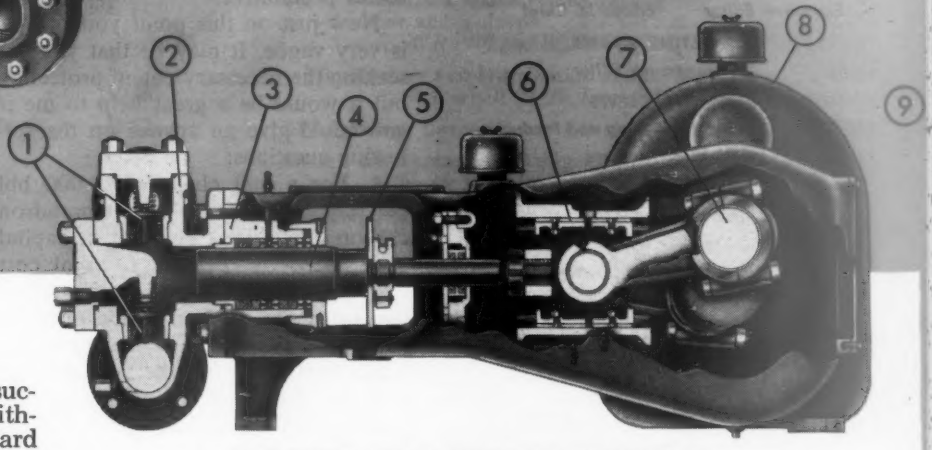
TULSA, OKLAHOMA

See "Oilwell's" New 4-in. Stroke Triplex *Plunger Pumps for Waterflooding*



. . . and other high pressure use

. . . with features that
Improve PERFORMANCE
Reduce MAINTENANCE



1. **VALVE ARRANGEMENT** . . . is such that suction valves can be removed for servicing without disturbing discharge valves. Standard valve service is of bronze. Suction and discharge valves are interchangeable.

2. **FLUID ENDS** . . . provide two suction and two discharge connections and can be furnished in bronze or cast iron.

3. **STUFFING BOXES** . . . are individually removable through the frame cradle without disturbing fluid cylinders.

4. **PLUNGERS** . . . can be furnished in hardened steel, Colmonoy, or porcelain enamel. Separate stud rods permit plunger changes without disassembling the crossheads.

5. **FLEXIBLE BAFFLES** . . . on each plunger extension prevent liquids, which might leak past the plunger packing, from reaching the diaphragm packing and entering the power frame.

6. **CROSSHEADS** . . . are equipped with renewable shoes and have full floating crosshead pins that are case hardened and finish ground to insure proper fit and long wear.

7. **CRANKSHAFT** . . . is of forged alloy steel fully heat treated and can be direct connected to slow-speed drives.

8. **A GEAR REDUCTION UNIT** . . . which can be mounted on either side of the pump frame, can be furnished for high speed drives.

9. **HEAVY-DUTY BEARINGS** . . . on all revolving shafts are of the adjustable, tapered roller type.

DISPLACEMENT AND HORSEPOWER REQUIREMENTS

Plunger Size, Inches	Max. Working Pressures, psi	DISPLACEMENT Barrels per 24 Hours at Pump Speeds (rpm) of: 80	120	160	180	200	220	240	250
No. 334-P—2	1,600	449	673	900	1,010	1,123	1,230	1,348	1,405
2¼	1,260	564	847	1,128	1,270	1,411	1,552	1,698	1,765
2½	1,020	702	1,054	1,405	1,581	1,757	1,932	2,108	2,195
2¾	840	841	1,261	1,682	1,892	2,102	2,313	2,523	2,630
3	700	1,002	1,503	2,004	2,255	2,505	2,756	3,006	3,130
No. 344-P—3¼	605	1,180	1,772	2,360	2,660	2,960	3,260	3,540	3,700
3½	520	1,370	2,060	2,740	3,080	3,430	3,780	4,110	4,290
4	400	1,786	2,678	3,571	4,018	4,464	4,910	5,357	5,580
Pinion Shaft rpm: Gear Ratio, 4:45:1		356	534	712	801	890	978	1,067	1,110
Brake Horsepower Required		14.0	21.0	28.5	32.0	35.5	39.0	42.5	44.5

For larger waterflooding requirements, see "Oilwell" 6-in. and 8-in. stroke triplex plunger pumps.

WHEN YOU . . . have pumping applications that call for dependable performance, let your "Oilwell" Representative quote on the type from our complete pump line that will meet your requirements — MOST ECONOMICALLY.

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UNITED STATES STEEL CORPORATION

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Export Office—
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"OILWELL"
TRADE MARK

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XUM

THE *Petroleum* ENGINEER

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LETTERS ★

Coke Information Wanted

Your article "Metallurgical Coke from Petroleum Pitches" (Reference Annual issue, July, 1954) has been read here with considerable interest. On the one hand we have an abundant supply of heavy crudes, on the other hand the Venezuelan Government wants coke for its own industry plans. Fluid process coking yields a coke with too high sulphur content and cost of conversion into low sulphur coke seems prohibitive.

Now just on this point your article is very vague. It may be that you are seeking the necessary patent protection but it would be a great help to me if you could give an answer on the following questions:

1. For a unit charging 10,000 bbl per day of 35-90 per cent Conradson carbon pitch; what per cent of capital cost would be required of total cost for the "sulphur control unit" assuming 5 per cent sulphur in the pitch?
2. Can you give any idea how the S is removed? From the flow scheme I gather that H_2S is unlikely, so remain SO_2; COS or CS_2.
3. How much coke is lost during S removal?
4. Any possibility of reclaiming S as sulphuric acid?

I should be very much obliged if you could let me have some idea on these points since it might change considerably our ideas in which direction further refining expansion ought to go.

Dr. Si Van Der Baan
Advising Technologist
c/o Shell Refinery, Punta Cardon
Estado Falcon, Venezuela

(Editor's Note: Above letter was addressed to M. D. Curran. His reply is below.)

Your letter of September 14th, which you forwarded to **The Petroleum Engineer Publishing Company,** has just been received by us and we are pleased to respond to it as follows.

We are in the process of securing necessary patent protection for our desulfurizing process and for that reason I did not go into any detail at the San Antonio meeting. We are still not in the clear on this patent matter, but I do want you to have as much information as we can give you. We are pleased to answer your questions as follows.

1. The sulfur control unit will comprise between 15 and 20 per cent of the capital cost of the complete plant.
2. The sulfur is removed as hydrogen sulfide.
3. The loss of coke in desulfurization runs from 15 to 20 per cent of which about 2 per cent is the volatile matter in the coke consumed during the desulfurizing operation.
4. The hydrogen sulfide produced can, of course, be converted to sulfuric acid or elemental sulfur by the utilization of existing types of sulfur recovery plants. We did some work about a year ago for a Dr. Harry Sykes of Caracas, who is a petroleum consultant and with whom you might talk about our process. He is quite familiar with our coking equipment, although at the time he visited our pilot plant we did not have the desulfurizing unit in operation. Dr. Sykes has often talked about the application of our coking method to the heavy high sulfur crudes of Venezuela, and therefore it might be worth your while to talk with him if you have an opportunity.

Venezuela does have some coal the character of which we are not familiar with although a sample is now on the way to us for examination. We have had in mind that even if the larger coal reserves of Venezuela were of the non-coking variety we could make a satisfactory coke for the steel industry by blending a petroleum pitch with such coal. I am enclosing herewith a copy of a paper which was presented at Bogota about two years ago giving our thoughts on the art of blending petroleum pitches with low grade coking coals, which I trust may be of some interest to you.

We shall be pleased to hear from you further if there is anything we can do to assist you.

M. D. Curran
President
Curran Carbonizing and
Engineering Company
Kirkwood 22, Missouri

Appreciates Job Photo

Thanks for the photo sent to M. B. Jaeger on September 15 showing Associate Pipe Line Contractors' 22-B Dragshovel trenching on a job near Tylertown, Mississippi. The job is on the Transcontinental Gas Pipe Line Corporation's 36-in. diameter pipe line being laid for natural gas transmission through Mississippi and into Alabama. (Oil . . . Gas . . . Products Pipelining Edition, October Issue, 1954). We appreciate your bringing this job photo to our attention.

Milton T. Kojis
Publicity Department
Bucyrus-Erie Company